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ЧВОВЕДЕНИЕ

SOVIET SOIL SCIENCE

3

MARCH 1961

A TRANSLATION
OF POCHVOVEDENIYE

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AMERICAN INSTITUTE
OF BIOLOGICAL SCIENCES
2000 P STREET, N.W.
WASHINGTON 6, D. C.

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The translation and publication of this and other Russian language biological journals and monographs is a project of the American Institute of Biological Sciences. This project is supported by grants from the National Science Foundation. Each publication is a cover-to-cover translation of its Soviet counterpart and the contents are only those of the original authors.

Pochvovedeniye in English translation bears the Soviet issue numbers. The Soviet journal carries no volume numbers. Translation begins with Number 1, the January 1958 issue. It is published in the same number of issues per year as the original Soviet journals: 12 issues.

translated and produced by
ROYER & ROGER, INC.
INTERNATIONAL DIVISION

Subscription Prices:
$40.00 per year, individuals and industrial libraries
20.00 per year, university and non-profit libraries
3.00 additional to each price for foreign orders
4.50 each, single copies

Order from:

American Institute of Biological Sciences
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SOVIET SOIL SCIENCE

A translation of the monthly journal—POCHVOVEDENIYE—
a publication of the V. V. Dokuchayev Institute of Soil Science,
Academy of Sciences, USSR. A journal founded in 1899.

Pochvovedeniye Editorial Board: I. V. Tyurin (editor-in-chief), I. N. Antipov-Karatayev, N. I. Gorbunov, K. P. Gorshenin. A. A. Zavalishin, V. N. Zavaritskii, S. V. Zonn (assistant editor), O. K. Kedrov-Zikhman, V. M. Klechkovskii, V. A. Kovda, M. M. Kononova (assistant editor), Ya. V. Peive, I. I. Sinyagin, A. V. Sokolov

No. 3: March 1961 Translation printed: February 1962

CONTENTS

	Page	Russian Page
SALT EXCHANGE BETWEEN THE SEA AND THE LAND, AND LONG-TERM DYNAMICS OF SOIL PROCESSES, by V. M. Borovskiy	237	1
WATER REGIME OF TROPICAL FOREST SOILS, by S. V. Zonn and Li Chen-Kvey	245	12
INVESTIGATIONS OF THE DYNAMICS OF WATER STABILITY OF SOIL AGGREGATES, by A. Kul'man and A. Klimes-Chmik	253	23
SEASONAL DYNAMICS OF THE CHEMICAL COMPOSITION OF LYSIMETER WATER IN PODZOLIC FINE CLAY LOAM SOILS, by Ye. I. Shilova and L. V. Korovkina	263	36
WATER REGIME OF PEAT SOILS IN SUMMER UNDER CONDITIONS OF THE MESHCHERSK LOWLANDS, by B. S. Maslov	273	48
METHODS		
MELIORATIVE EVALUATION OF IRRIGATION WATER WITH ALKALINE REACTION, by I. N. Antipov-Karatayev and G. M. Kader	283	60
MICROELEMENTS IN THE SOILS AND PLANTS OF USTYURT, by V. V. Dobrovol'skiy	288	65
COMPARATIVE CHARACTERISTICS OF SOD-PODZOLIC FOREST SOILS IN VARIOUS STAGES OF CULTIVATION, by A. S. Konovalova	293	71
DECOMPOSITION OF PLANT RESIDUES IN THE SOIL, by V. N. Kuranov	300	78
EFFECT OF PLOWING DEPTH OF ORDINARY CHERNOZEM ON THE ELEMENTS OF SOIL FERTILITY AND ON CROP YIELDS, by D. P. Burnatzki and V. V. Yarovenko	305	83
EFFECTS OF DRAINAGE ON WATER PROPERTIES OF CLAY AND CLAY LOAM SOILS, by Ye. Andriyauskayte	312	89
DETERMINATION OF MOISTURE OF FRIABLE SUBSTANCES BY ELECTRO-CONDUCTIVITY, by D. N. Onchukov	319	95
QUICK DETERMINATION OF TOTAL PHOSPHORUS IN SOILS, by I. I. Takhtay and L. I. Lyubchenko	322	98

	Page	Russian Page
A MODIFICATION OF TYURIN-KONONOVA'S METHOD OF DETERMINING READILY HYDROLYZABLE NITROGEN, by S. G. Gol'dberg	325	101
WORK OF COMMISSION V OF THE INTERNATIONAL SOCIETY OF SOIL SCIENCE AT THE SEVENTH INTERNATIONAL SOIL CONGRESS IN THE USA, 1960, by E. V. Lobova	327	103

CHRONICLE

	Page	Russian Page
SIXTIETH BIRTHDAY OF V. M. KLECHKOVSKIY	337	113
FIFTIETH ANNIVERSARY OF YA. YA. TOMASHEVSKIY'S SCIENTIFIC ACTIVITY, by The Polish Society of Soil Scientists, Union of Soil Scientists	339	116
REPORT OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS, 1960, by N. A. Razorenova	340	117
SYMPOSIUM ON SOIL FAUNA IN VIENNA, by M. S. Gilyarov	344	120
LETTER TO THE EDITOR – OPEN-PIT WORKINGS OF USEFUL MINERALS AND THE QUESTION OF PROTECTING SOIL RESOURCES OF THE COUNTRY, by S. A. Aristov	346	122
ALEKSANDR VASIL'YEVICH MUKHLYA (1887-1960), by the Staff of the Chair of Soil Science, Kazakh Agricultural Institute	347	123
BIBLIOGRAPHY	348	124

SALT EXCHANGE BETWEEN THE SEA AND THE LAND, AND LONG-TERM DYNAMICS OF SOIL PROCESSES

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Water soluble salts are widely distributed in soils of various types. In arid regions, which occupy about one-third of the land surface, they determine to a large extent the properties of the soil and its suitability for agriculture. Therefore, development of the theory of salt migration in the soil is of a great practical and theoretical interest.

Water-soluble compounds, the most mobile part of the soil, are the "mobile function" of the hydrothermic regime, of geological conditions, and of the activity of the biosphere. Polynov proved that the movement of substances in the zone of hypergeneses takes place not in strict accordance with the solubility of compounds as claimed by Fersman, but in a different manner which he called migration capacity, explained by the effect of colloids and by the superimposition on the abiotic process of complicated biological cycles of conversion of matter. The schemes of distribution products of weathering on geomorphological elements set up by Polynov (22-23) characterize the distribution of salts in accordance with local ridges and depressions and also give the total migration of elements from the land into the ocean. Kovda, (14, Vol. 1, page 18), in developing Polynov's thesis, wrote that during geological time the balance of the salt circulation between land and ocean was in favor of the ocean and the supply of salts in the ocean no doubt was increasing.

Now additional data have accumulated which support this premise. In what follows, we shall attempt to examine briefly the question of salt exchange between the sea and the land during geologic times and the character of the dynamics of salts in the soil over periods longer than seasonal cycles.

As is known, the equation of the water balance of the earth is as follows. The quantity of water evaporated during a year from the surface of the ocean equals the amount of precipitation falling on the surface of the ocean plus the quantity of water which runs off from the land into the ocean in a year (i.e., the continental run-off). Zero value of the net balance (external moisture cycle) insures relative stability of the level of the ocean. It follows that during long periods of geologic time, the land is being flushed through continually by precipitation. Mobile products of weathering and of soil formation are carried out by the water from the continents into the ocean.

On this premise is also based the idea of gradual salinization of the oceans during geologic history (Galley, Dzholi, Fesenkov, and others). The computations of the quantity of salt which is annually brought into the ocean in this manner served as the basis for the calculation of the age of the ocean based on the sodium content (Dzholi). As is known, the age of the ocean was thus determined to be 156×10^6 years. A refinement of this calculation based on average conditions of intensity of denundation gave a value of 330×10^6 years (Holmes). These calculations gave a much reduced age of the oceans because no account was taken of the fact that the salts brought into the ocean from the land are at least partly of oceanic origin, that salts are not only brought into the oceans by rivers, but are also carried out of the ocean by wind as marine and lagoon deposits (18).

Bertolle was the first to call attention to the possibility of the wind carrying salts from the sea onto the land. He explained the salinization of lakes in the Nile delta in this manner. Clark (36) pointed out that the salinization of Lake Sambar which is 400 miles from the seashore is due to salts brought in by the wind.

Determination on the Caspian Sea showed that the amount of salt brought from the sea onto the land constitutes 30% of the salts brought by continental run-off from the land (5).

Part of the salts brought from the sea by wind settles on the land and part is carried out by the higher layers of the atmosphere. Studies of these layers of the atmosphere showed that they contained ions of sodium—"sodium can be brought in particles of salt from the ocean" (1, page 575). It is thus quite probable that sodium of ocean salts forms a part of the ionic atmosphere of the earth which extends to a considerable height (according to Astapovich the maximum luminosity of sodium is noted at a height of 86 km). In spite of its relatively low density the ionic atmosphere can contain a large amount of salt. No other important source of accumulation of sodium ions in the atmosphere is known. It follows that the atmosphere plays an active part in the exchange of salts between the land and the ocean.[1] Vernadskiy and Polynov proved that weathering is not sterile and that everywhere it is brought about with the participation of organisms. This means that the ionic atmosphere of the Earth is in some sense a product of life, a product of soil formation, and of weathering.

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[1] A quantitative determination will be possible after the analyses of the data accumulated by the IGY Program of artificial satellites of the Earth.

A study of the iron quartzite deposits of the Proterozoic ocean, of South Africa (the system Namma Transval), makes it possible to suppose that the ocean then was very low in salt (27). However, these data, as pointed out by Blinov (4), are only circumstantial evidence and cannot be accepted unconditionally. Yet, it would be very important to find indications that would lead to judging the salinity of the oceans in the past which would make possible direct determination of the composition of the water in the oceans during past geologic eras. The Zechstein Sea (4) which existed on the territory of Germany gives such indications. It was separated from the ocean and completely dried out at the end of the Paleozoic era. The salt deposits were covered over by a deep layer of clay which prevented further leaching. With detailed studies of German authors (Rozsa and others) as a basis, Samoylov (25) computed the correlation between the ions in the Zechstein Sea. Blinov (4) derived the composition of contemporary oceans as a mixture of the water of the Zechstein Sea and of continental run-off, according to the rules and formulas of mixing of natural waters proposed by Molyarov (15), and constructed curves showing the changes in the composition of ocean water. In the graphs, he ploted on the abscissa the geologic time according to Arldt and on the ordinates the equivalent-per cent of salt-forming ions.[2]

Taking into account the correlation of salt-forming substances in the Zechstein Sea, in the ocean, in the continental run-off, and in the products of volcanic activity, Blinov (4) computed the probable salinity of the oceans in the past. At the end of the Archeozoic time or the beginning of the Paleozoic time, it constituted 10%-14%. At the time of the drying-up of the Zechstein Sea it was 26.1%, and at the present time it is 35%. Therefore, as is seen from direct data, the ocean in the past contained considerably less salt than now and was salinized gradually in the course of geologic history.

Contemporary oceans, according to Link, contain about 20 million km^3 of salt. According to Lindgren and to the computations of Kovda (14, Vol. 1, page 18) the salt content of the land is about 17 million km^3. There are grounds to believe that the total quantity of salt-forming matter in the great geologic cycle could not change greatly during geologic time because all the original rocks went through a cycle of weathering already in the proterozoic time. This means that the distribution of the total salts at the end of the Archeozoic or at the beginning of the Paleozoic time can be provisionally expressed, as follows: ocean—5.7 million km^3; land—31.3 million km^3. If we consider that a part of the salts is carried out into the cosmic space surrounding the Earth and forms the ionic atmosphere of the Earth, then it is probable that in the past the quantity of salts on the land was even greater.

Thus, the exchange of salts between the land and the ocean, in spite of the process of "impulverization" and the carrying out of the salts onto the lands in marine deposits, is still in favor of the ocean. During geologic time the amount of salts in the ocean increases, and on the land decreases. The salt exchange between the land and the ocean is a directed process, its resultant is in the direction from the land to the ocean. In this movement from the land to the ocean, chlorides which have a high migration capacity must overtake the sulfates and must accumulate more rapidly in the sea.

A study of the geochemistry of halogens led Korrens (16, p. 273) to the conclusion that "halogens are concentrating in sea water."[3] One can suppose that in the past salinized soils were more prevalent than now, and that they often contained the more harmful chlorides.

Gerasimov (10) set up a series of stages in the development of the organic world: the primary (before the Paleozoic and in the Lower Paleozoic), which is characterized by a relatively rapid rate of development of the organic world in the ocean and by a slow rate of development of the primary flora on the land; the transitional (during the Upper Paleozoic and the Mesozoic), when the rate was on the whole more uniform; the later (during the Cenozoic time), which was characterized, in contrast with the primary, by a more rapid tempo of evolution of biocoenoses on the land and by a retardation of the evolution in the ocean. Paleontology gives a great number of facts supporting this conclusion, it is entirely indisputable. The great majority of contemporary marine animals had their primeval representatives in the Cambrian Sea.

On the other hand, the great majority of land organisms originated considerably later. Along with other causes in this process, an important role could have been played by the gradual removal from the land of harmful salts and their accumulation in the sea. As a result, edaphic conditions on the land have on the whole improved during geologic time, and in the sea they deteriorated.

The improvement of soils during geologic time proceeded, of course, not only as the result of leaching out of harmful salts which concentrated in the seas. This process, along with others, while promoting the acceleration of the evolution of biocoenoses on the land, led to the creation of more complex organisms. These organisms absorb from their surroundings various elements and compounds that are thus brought into the minor biological circulation of matter. These elements and compounds have in the end concentrated in the soil. Therefore, with the evolution and the complexity of land organisms, the soils were enriched by an increasing quantity of various elements—organogens. The soils received organic matter of a more complex composition which in the process of their transformation formed organic soil horizons. Phylogenesis of soils in geologic time is interconnected with the process of evolution of organisms. Primitive soils corresponded to primitive organisms. More complex organisms corresponded to soils rich in a variety of organogens with complex composition of humus. The soluble elements and their compounds which were useless or even harmful for the organisms were not absorbed by them. For instance, chlorides which gradually were leached out and were carried away by the runoff from the continents into the ocean.

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[2] Arldt determines geologic time in relative units; Cenozoic —0.3; Mesozoic —0.75; Paleozoic—7.5; Archeozoic—9.5. One unit corresponds to approximately 10 million years.

[3] On the basis of new works of Ruby, Kurod, Sandell, and Conway, Korrens (16, page 266 and 275) gives the following computation of the chloride balance: The total chloride content in the ocean is taken to be 2.8 x 10^{22} g. Its period of accumulation is 3 x 10^9 years. Therefore, every year the ocean receives 10^{13} g of chloride but the data of Conway show that the land receives annually 0.69 x 10^{14} g of chloride which is considerably more than the computed flow into the ocean. It is quite obvious that the calculation is incorrect because no account is taken of the removal of salts into the atmosphere and into marine deposits.

Just as ontogenesis of organisms repeat their phylogeneses, so the development of contemporary soils on crystalline rock can be considered as the ontogenesis of soils which appears to be repeating the complicated and lengthy route of soil phylogenesis. This process, which was thoroughly studied by Polynov (24) and his students, consists of displacement of the microbial population on rocks by surface lithophyllic lichens and then by plastic lichens and mosses, etc. These lichens and mosses gradually create primitive soils, which in turn prepare the substratum for an increasingly complex group of organisms. The process of formation of contemporary soils proceeds very rapidly. It takes only a few years, because the evolution of organisms has already prepared the necessary changes and biocoenoses. On the other hand, the course of phylogenetic development of soils required many millions of years of evolutionary process in order that the biocoenoses of primitive organisms could be replaced by more complex ones.

In the concept of improvement of soils during the course of geologic time, we include the notion of soils freeing themselves of harmful substances and gradually enriching themselves with elements and compounds which are brought into the biological circulation with the increase in complexity of organisms in the process of their evolutionary development.

The considerably richer species on the land in late geologic time is attested to, for instance, by the fact that insects alone on the land have more varieties than all of the classes of marine organisms put together. The land now has not only a greater number of new classes and varieties which appear in the later geologic time, but also a higher density of the organic population. The intensity of life in the sea cannot be compared with that of the land. One gram of soil contains billions of microorganisms of a great variety: bacteria, fungi, actinomycetes, and protozoa, whereas seawater contains fewer of these simplest and more of the complex organisms.

In the previously cited work, Gerasimov (10) calls attention to the fact that moisture-loving paleozoic flora is replaced in Mesozoic times by new vegetation which gravitates to physiologically dry stony and sandy habitats. Here it should be kept in mind that up to the Carboniferous period and including it nothing resembling the contemporary flora of steppes and deserts existed. The continents of the Carboniferous period were in their greater part large deserts (15). Walter (9) considered that even the plains which were weathered by rain were devoid of vegetation at that time. Surface vegetation first began to develop in valleys and in delta regions of large rivers. This moisture-loving vegetation of the Paleozoic swamps in the flood plains while conquering the Mesozoic land, originally adjusted itself to the physiologically dry, better-drained localities, i.e., to places where the soil was less saline. On the plains the soils were probably more saline than now, and adjustment to them required more involved, more complicated, reconstruction of the organisms. Here (on the plains), in the Jurassic and Cretaceous periods, appeared the halophytes (12, 20).

The tendency of salts to move from the land to the sea was determined by the external moisture circulation and took place during the entire geologic time.[4]

In the process of development of the Earth's crust there were formed in certain areas regions without outlets to the ocean. In such places a process of continental accumulation of salts is developed which is regulated by the local internal moisture circulation.[5] On route from watersheds to local bases of accumulation, soluble compounds distribute themselves in a definite order. In accordance with their migration capacity, they form a series of residual and accumulated crusts of weathering which displace each other from the top to the bottom of the relief. This was shown convincingly on many examples by Polynov (22, 24). The duration of the existence of such enclosed regions corresponds to tectonic stages of development of the Earth's crust, and in geologic concepts of time can be considered as local temporary retention of salts on their way to the ocean. Conditions change with the passage of such parts of the crust into a new tectonic state. These changes were in the past more frequent than now because the development of the geotectonic process "is characterized by its general direction towards tectonic rest of the Earth's crust, its stabilization" (3, p. 501).

The movement and distribution of salts from watersheds into local bases of accumulation in such regions is determined by the migration capacity of the elements and of their compounds. It is entirely analogous to the processes discussed previously, and in miniature reproduces the laws of movement of salts from land to the ocean which hold for the entire globe.

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[4] In geography, the external moisture circulation is taken to be the circulation of moisture between the land and the ocean.

[5] Internal circulation in geography is understood to mean the circulation of moisture in closed regions without outlets. The net of the water balance of such regions is nearly zero because if as a result of evaporation the inflow of moisture exceeds the outflow, such a region inevitably becomes a water basin and acquires an outlet. The opposite relationship in the balance (i.e., the excess of outflow over inflow) is impossible or can continue only a short time, while the supply of water will not be used up and a certain equilibrium will be reached.

Along with the general tendency of translocation of salts from land to the sea in geologic time, there is in nature a continuous local movement of salts in the soil and in the crust of weathering a study of this movement is of great practical interest.

The accumulated data for Central Asia and Trans-Caucasus were summarized by Kovda (14), who proposed that there should be distinguished seasonal cycles of winter-spring leaching and of summer-autumn restoration of salinity. For locations with other hydrologic and climatic regimes such cycles would have a somewhat different character. For instance, for the monsoon climate of southeastern Asia these would be cycles of summer leaching and autumn-winter salinization, etc. In irrigated soils, the seasonal regime is more complex and is composed of cycles of leaching during irrigation and precipitation periods, and of accumulation of salts during periods between irrigations and during dry periods.

According to Kovda the long-term regime of salts can be of three types: if from one seasonal cycle to the other the salts in the soil are increasing, then this would be a long-term regime of salinization; if it is decreasing, it is desalinization; and a third intermediate case, when salinization remains stable.

The migration of salts in seasonal and long-term cycles is thus functionally connected with the hydrologic, climatic, and hydrogeologic regimens of the territory (and for cultivated soil also with manner of their utilization). It is clear from this that to find the pattern of long-term salt regimen of soils, it is necessary to determine the character of the changes of the indicated attributes.

The seeking of the pattern of rhythmic hydrologic and climatological phenomena is not new. Such attempts were made many times. One could mention the thirty-five year cycles of Bruckner which according to him were applicable to the entire Earth. Then there are the attemps of Berg, Kennen, Wagner, and Leslie. Of special interest are the ideas of the Belgrade professor, Milankovich (19) who established cycles of geologic duration.

Extremely promising results were obtained from the study of the relationship between the Earth and the Sun. This trend gradually crystallized into a special science—Heliogeophysics. Seeking such connection is justified by the fact that the Earth is a planet which is governed by the Sun. The development of organisms, many exogenic geologic processes, and some geophysical phenomena are closely related to the energy received by the Earth from the Sun. It is quite natural to assume that changes in solar activity cannot but be reflected in these processes. However, these relationships are very complex and their study is connected with many difficulties.

The relation of some geophysical phenomena to solar activity is widely known, is well investigated, and is widely accepted. These are geomagnetic disturbances, northern lights, and disturbances in the regularity of the structure of the ionosphere, which cause appreciable changes in the reflection of radio waves. However, the relations of tropospheric phenomena to solar activity is often very difficult to determine.

While the theory of the relation of the physical state of the troposphere to solar activity is extremely complex and by far not yet clear, there are many attempts to relate meteorological elements to the Wolfe numbers.[6]

A summary of a number of papers devoted to this problem was given in several works (32, 34). We shall cite some of the data resulting from these investigations.

B. M. Rubashev (32) cites the correspondence of a curve of Wolfe's numbers to mean annual temperatures for tropical and temperate latitudes according to Nansen and Heland-Hansen. This graph shows convincingly enough the existence of a relationship between these functions.

M. S. Eygenson (34) investigated the well-known classical example of the relation of fluctuations of water levels in Lake Victoria to solar activity (to the sun spot number W). As is known these curves conformed up to 1925 and then (as some authors think) this correspondence was destroyed. However, Eygenson quite correctly points out that the extremes of these curves correspond even after 1925 and, therefore, the relationship became more complex, but certainly was not destroyed.

In 1939, Rubashev developed the "method of reflections" with the aid of which he showed the relationship of solar activity to Arctic and Azore eruptions.[7]

Eygenson (34) in his generalizing paper gives a summary of investigations which show the relationship of solar activity to many hydrologic and climatologic phenomena as well as to the development of organisms. For example: 1) the level of the Caspian Sea, by means of atmospheric circulation, is a function of a phase of solar activity; 2) Shevedov and Douglas indicate the relation of annual tree rings to solar activity; 3) Shcherbinovskiy established the relationship of the breeding of locusts in India and Severtsev of the biology of mice to solar activity; 4) Berg discovered that endemic sicknesses (cerebral spinal meningitis) increased during periods of maximum solar activity; 5) Mostakovich noticed the relationship of the rate of growth of corals with cycles of solar activity; 6) Nikol'skiy pointed out that the number of fish (and Fortunatov showed that catches of fish) in the Aral Sea are related to

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[6] With the increase of activity, there is an increase in sun spots. The astronomer Wolfe proposed to indicate solar activity by a number of sun spots (W) which later were called Wolfe's numbers.

[7] For details see M. S. Eygenson (32), part 4, chapter 3.

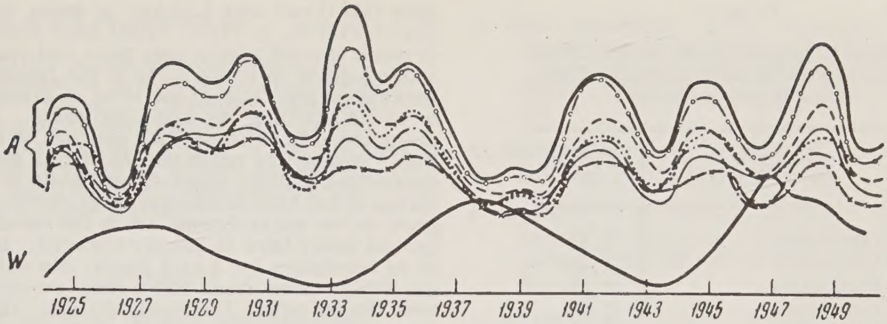

Fig. 1. - Comparison of mean annual discharge of the Syr-Dar'ya River with solar activy (Wolfe's numbers).

Legend: W - Wolfe's numbers. A - mean annual discharge in m^3/sec for the following stations (from the top down): Kampyr-Ravat; Zaporozhskaya; Kok-Bulak; Tyumen'-Aryk; Kara-Uzyak; Karmakchi; Kazalinsk.

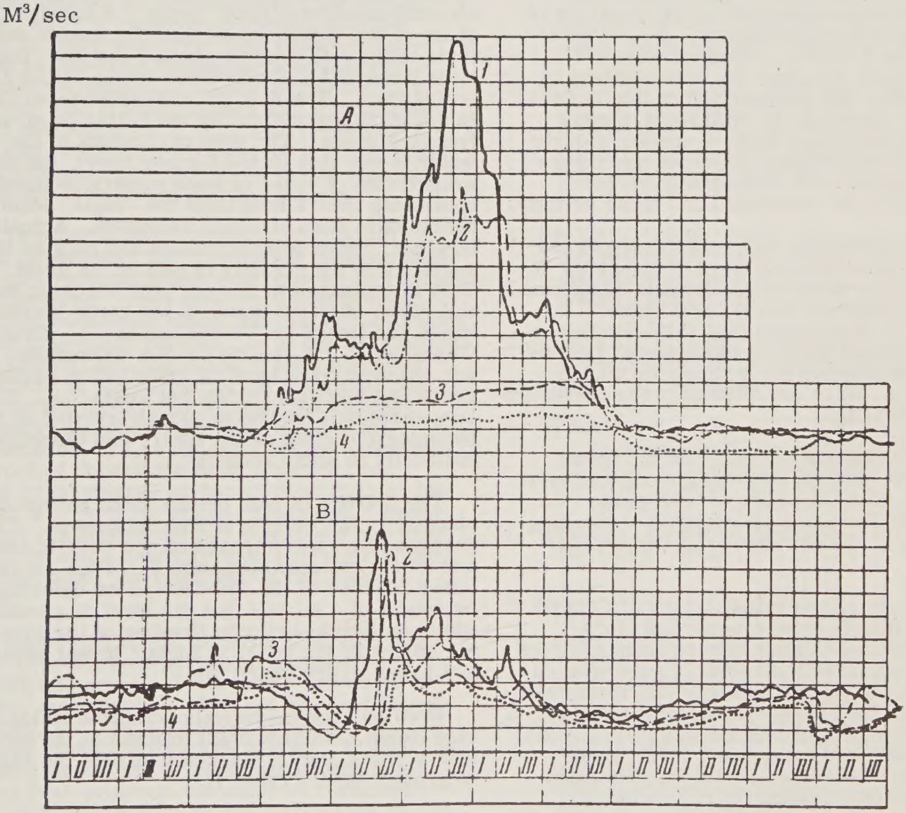

Fig. 2. - Graph of discharges of the Syr-Dar'ya River: A - 1934 (high flows); B - same for 1950 (low flows).

Hydrometric stations: 1 - Kok-Bulak; 2 - Tyumen'-Aryk; 3 - Karmachki; 4 - Kazalinsk.

the 11-year solar cycles (the difference in catch for an 11-year cycle reaches 150,000 centners); 7) Eygenson and others showed the relation of Arctic ice to cycles of solar activity; and 8) Schultz (30), on the basis of numerous long-term investigations, established the relationship of the activity of the blood-producing apparatus to solar activity (increase in lychocytes and lymphocytes during the stages of maximum).

The closest to the theme of our paper are the investigations of Brodovitskiy and Predtechenskiy (8), Tokarev (28), and Kenesarin (13). The first authors established a clear connection between the stream flow of the Syr-Dar'ya River and the atmospheric precipitation in its basin on the one hand, and solar activity on the other. From the graph constructed by them the effect of the Sun on minimum stream flow is clearly seen.

Table 1

Mean depth to ground water on the Kyzyl-Ordinsk experimental rice field before flooding in the spring

Year	Hydrologic characteristic	Depth, m
1947	Low water	2,17
1948	Low water	2,44
1949	High water	1,95
1950	Low water	2,06
1951	Low water	2,56

Note: Comma represents decimal point.

Tokarev (28) used the methods of comparing the integrals of the curves of Wolfe's number with annual sums of precipitation and fluctuations of water levels in enclosed basins. He correctly states that the Aral Sea, being an enclosed basin, serves to integrate the precipitation on the watershed. The comparison of the fluctuation of water levels in the Aral for a century with integral curves of Wolfe's number clearly proves their relationship to the Sun and therefore the existence of a relationship between precipitation on the watershed and solar activity.

Tokarev showed that the relationship of precipitation to solar activity is very complex. It depends on local physical-geographic conditions and can be divided up into several types. Kenesarin (13) discovered that rhythmic fluctuations of ground water in the oases of Central Asia have secular (80 years) and shorter (11 years) cycles, which correspond to the rhythmicity of solar activity.

Figure 1 shows the comparison of stream flow of the Syr-Dar'ya according to hydrometric stations with Wolfe's number. The graph clearly shows the close relationship of the long-term regime of the Syr-Dar'ya River to solar activity.

On the broad alluvial delta plains of Central Asia the regime of ground water and of the water-salt regime of soils depend largely on the hydrologic regime of the rivers. According to the observations of Pogrebinskiy (6), there was established in the lower reaches of the Syr-Dar'ya River a relationship between the regime of ground water and the regime of the river which, as seen from the aforesaid, is related to solar activity. Comparing hydrographs of upper and lower hydrometric stations for low water and high water years shows that in the wet years they are quite different. In the upper stations, there are high discharges, and in the lower stations the flow is small (Fig. 2, a). During low water years the hydrographs of these stations are comparable (Fig. 2, b). This is explained by the inundations during the high wet years which cover the vast lowlands of the alluvial plains. During dry years inundations either do not take place at all or they are small, and involve only a small portion of the total flow. Observations show that the difference in the discharge of the Syr-Dar'ya at Kok-Bulak and Kazalinsk reaches 16.34 km^3 in a wet year (1934) and only 2.33 km^3 of water in a dry year (1947) (6, p. 110). These huge quantities of water spread over a vast plain and cause water logging in lower parts of the relief and a general marked rise in the level of ground water on areas adjoining the inundated parts. In these areas there is an intensified process of salinization. During dry years the inundating water is evaporated and the water-logged soils dry out. Owing to the high transpiration of reeds which grow on the water-logged areas the level of ground water here is quickly lowered. If there is no inundation for 2 or 3 years, the soil is gradually transformed into a meadow-bog and even desert type. The reeds die out. On the areas adjoining the depressions, where during wet years there were formed wicklike solonchaks, the salinization stops during dry years with the lowering of the ground-water levels.

Along the stream beds in Central Asia and in southern Kazakhstan there are everywhere alluvial-meadow—"tugai" soils. A careful study of the conditions of their formation and of their water-salt regime showed that the "tugai" soils have high ground-water levels during the entire year. The high ground-water level (1.5 to 2.5 m) is maintained by the filtration of water from the river. The mineral content of the water is not high (0.5-3.0 g per liter), but with evaporation of water of such mineral content continuing over a long time the "tugai" soils should have been strongly salinized. Actually, however, these soils are salinized only on the surface and the quantity of salt is not great. This is explained by the periodic leaching during wet years when the water of the river leaves its banks and floods the "tugai" soils (7). Thus, the "tugai" soils, in contrast to the solonchaks, are characterized by slow salinization during dry years and leaching during wet years; i.e., their long-term salt regime is closely related to the hydrologic regime of the river, and therefore, indirectly to solar activity.

The activity of man brings about enormous changes in the regime of soil processes. These changes are superimposed on the cosmic rhythm and do not entirely eliminate it. Thus, in the lower reaches of the Syr-Dar'ya we determined by means of a survey that the level of ground water on fields, prior to flooding of the rice in the spring of the year, is higher in wet years and lower in dry years (6).

Even on such intensively irrigated fields as rice fields, the hydrologic regime of the territory of the region markedly affects the regime of ground water (Table 1).

As was shown in the work of Tokarev (28), the regime of precipitation is closely related to solar activity. Therefore, not only the salt regime of soils, but many other soil processes which depend on moistures, are also related to solar activity.

During years with high precipitation in southern regions, ephemeral plants develop very rapidly and produce especially large quantities of organic matter. This organic matter enters the soil. Therefore, the process of accumulation of organic matter must have a pulsating character. In northern regions during wetter years, there is an intensification of the processes of leaching and of water-logging.

The activity of soil microorganisms is strongly dependent on the hydrothermic regime of their environment. Therefore, many complex processes of conversion of matter (decomposition and mineralization of organic matter, microbiosynthesis, organic weathering of minerals, etc.) must be connected with the pulsations of solar activity.

Conclusions

1. Salt exchange between land and ocean over geologic time leads to the accumulation of salts which are injurious to plants and to many other organisms in the sea, and to gradual removal of such salts from the land.

2. The most important factor of soil formation, the activity of organisms and the climatic regime, show a cyclicity connected with the rhythm of solar activity. This makes it possible to assume that the development of soil must also be related to a definite rhythmicity connected with cosmic factors and is characterized by periods of time of 11 and 79-80 years.[8] Cosmically explained cyclicity of soil biological, meteorological, and geological phenomena represents the most broad natural pattern.

3. Because of the long-term rhythm of natural processes, the boundaries between landscape-geographical zones and between soil zones cannot be fixed. They continually move north and south from some mean position in conformity with the long-term rhythmicity of cosmic factors. In this connection, the old argument about the encroaching of the forest on the steppe or the steppe on the forest can be resolved entirely differently than previously (for one and the same location, but at different times, one could find proof of the encroaching of forests on steppes or of steppes on forest depending on the changes of long-term cosmic rhythms). These rhythmic changes of natural conditions can also explain the many characteristics of soils of the transition zone, for instance, of the forest-steppes.

4. Mastering of the patterns indicated previously represents a particularly important scientific and practical interest. They are, however, complicated, have not been sufficiently studied, and are not clear. Specially organized investigations are needed. It would be necessary to include in the international geophysical year program the study of cosmically determined rhythmicity of land processes in accordance with a unified program.

Received May 18, 1960

BIBLIOGRAPHY

1. ASTAPOVICH, I. S. 1958. Meteoric phenomena in the atmosphere. Gos. Izd. fiz.-mat. liter., Moscow.
2. BELL, BARBARA. 1958. Fluctuations in solar activity as a cause of changes in climate (In the compendium of C. H. Shepley, Climatic Change). Izd. Inostr. lit.
3. BELOUSOV, V. V. 1948. General geotectonics. Moscow—Leningrad.
4. BLINOV, L. K. 1947. The origin of salt content of sea water. Meteorologiya i gidrologiya, Inf. sb. No. 4, 1946, and No. 4, 1947.
5. BLINOV, L. K. 1950. Uptake of sea salts into the atmosphere, and the role of the wind and salt balance of the Caspian Sea. Tr. Gos. okeanogr. in-ta, vyp. 15(27). Gidrometeoizdat, Leningrad.
6. BOROVSKIY, V. M., and M. A. POGREBINSKIY. 1958. The ancient delta of the Syr-Dar'ya and the northern Kyzyl-Kum. Izd. Akad. Nauk KazSSR, Alma-Ata, Vol. I.
7. BOROVSKIY, V. M., E. B. ABLAKOV, K. YA. KOZHEVNIKOV, and K. D. MURAVLYANSKIY. 1959. The ancient delta of the Syr-Dar'ya and northern Kyzyl-Kum. Izd. Akad. Nauk KazSSR, Alma-Ata, Vol. II.
8. BRODOVITSKIY, K. V., and P. P. PREDTECHENSKIY. 1940. Solar activity and discharge of the Syr-Dar'ya. Tr. Tashkentsk. geofiz. abs., No. 1.
9. VAL'TER, I. 1911. The laws of a formation of deserts at the present time and in the past. St. Petersburg.
10. GERASIMOV, I. P. 1951. Paleographical value of the teachings of Williams on the unified soil-formation process. Problemy fiz. geogr., Vol. XVI.
11. DZHOLI, D. 1929. History of the surface of the earth. Moscow.
12. IL'IN, M. M. 1958. The flora of the deserts of Central Asia, its origins, and stages of development. Mater. po istorii flory i rastit. SSSR, vyp. III, Izd. Akad. Nauk SSSR, Moscow—Leningrad.
13. KENESARIN, N. A. 1958. Formation of the regime of ground water or irrigated regions as exemplified by Golodnaya Steppe. Avtoref. doktorskoy dis. Izd. Akad. Nauk UzbSSR, Tashkent.
14. KOVDA, V. A. 1947. The origin and regime of salinized soils. Izd. Akad. Nauk SSSR, Vol. I, 1946, Vol. II, 1947.
15. KOMAROV, V. L. 1943. The origin of plants. Izd. Akad. Nauk SSSR. Moscow-Leningrad.
16. KORRENS, K. U. 1958. Geochemistry of Halogens. Sb. Fizika i khimiya Zemli. Izd. Inostr. liter.
17. MALYAROV, K. L. 1929. Chemical composition of water in the drillings of the

---

[8] There are also possible cycles of 5.5 and 22 years.

Grozni oil region. Tr. Neft. in-ta, vyp. 5.

18. MARKOV, K. K. 1951. Paleogeography. Moscow.

19. MILANKOVICH, M. 1939. Mathematical climatology and astronomic theory of climatic fluctuation. ONTI, Moscow—Leningrad.

20. NEVSKIY, S. A. 1937. Materials on the flora of Kugitanga and its foothills: Flora and systems of higher plants. 4, Tr. Bot. in-ta Akad. Nauk SSSR.

21. OL', A. I. 1948. About the double cycle of solar activity. Priroda, No. 8.

22. POLYNOV, B. B. 1934. The crust of weathering, Part. I. Izd. Akad. Nauk SSSR. Moscow—Leningrad.

23. POLYNOV, B. B. 1944. Contemporary tasks of the study of weathering. Izd. Akad. Nauk SSSR, ser. geologich., No. 2.

24. POLYNOV, B. B. 1956. Selected works. Izd. Akad. Nauk SSSR, Moscow.

25. SAMOYLOV, YA. V. 1921. The chemical composition of the Zekhshtein Sea. Izv. Ros. Akad. Nauk, page 409.

26. SOKOLOVSKIY, A. N. 1941. Salinized soils as one of manifestations of salt on the Earth's surface. Pochvovedeniye, Nos. 7-8.

27. STRAKHOV, N. M. 1947. Iron ore facies and their analogues in the history of the Earth. Tr. In-ta geolog. nauk Akad. SSSR, vyp. 73, ser. geologich., No. 22.

28. TOKAREV, N. S. 1950. Rhythmic fluctuations of climate and their effect on the regime of surface and underground water. Tr. lab. gidrogeol. problem. Akad. Nauk SSSR, Vol. IX.

29. FESENKOV, V. G. 1934. Cosmology of the solar system. Izd. Akad. Nauk SSSR. Moscow—Leningrad.

30. SHUL'TS, N. A. 1959. The effect of fluctuations in solar activity on blood production. Priroda, No. 6.

31. EYGENSON, M. S. 1945. The sun and climate. Priroda, No. 1.

32. EYGENSON, M. S., M. N. GNEVYSHEV, A. I. OL', and B. M. RUBASHEV. 1948. Solar activity and its manifestations on the earth. Gostekhfeoretizdat. Moscow.

33. EYGENSON, M. S. 1951. Geophysical manifestations of the secular cycles of solar activity. Izv. VGO, Vol. 83, vyp. 1.

34. EYGENSON, M. S. 1957. Essays on physical geographical manifestations of solar activity. L'vov.

35. EYGENSON, M. S. 1959. The sun, weather, and climate. Priroda, No. 4.

36. CLARKE, F. W. 1924. The data of geochemistry. Washington.

WATER REGIME OF TROPICAL FOREST SOILS

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The study of the water regime of soils is lately receiving a great deal of attention in the USSR and in other countries. The water regime of the major soil groups of the temperate and partly of the sub-tropical belts has been investigated more or less. In spite of the fact that tropical soils occupy large areas of the globe and are characterized by wide variations in the accumulation and disposal of moisture their water regime remains almost uninvestigated. Available data are quite fragmentary and deal largely with the determination of soil moisture in connection with the growing of particularly water-loving tropical plants (rubber, citrus and others). We have no knowledge of any publication on the water regime of tropical soils under natural forests of various composition, yet the knowledge of it in these soils presents great interest in connection with the finding of the peculiarities of the development of very complicated and contradictory tropical "ferrisialitic" and "ferrialitic" soils which are referred to as red earths, lateritic, yellow earths, and other groups.

It is with the aim of filling this gap that in 1959 we started the study of the water regime of soils in two moist tropical monsoon evergreen type of forest biogeocoenose.

1. The tall-trunk multi-story Geronniera with ferns (Plyocnemia sp.) understory. These contain from 25 to 30 species. The principal ones are: individual trees of Knema Wangii, Cinnamomum iners, with a height of 30 m, which stand above all the rest; trees of Geronniera subaeguna, with a height of 13 to 14 up to 20 m, there are more of these than of all other types. They include the following: Pouteria annamensis, Xanthopyllum siamense, Arytera littoralis, Acronyehia pedemeulata, Chisocheton paniculatus, Ficus altissima, Presmatemeris tetrandra, Randia junnanensis, Simplocos hookeri, Dalbergia slipulata, Litsea bavensis, Capparis viminea, Phoebe laneolata, Ixonanthus coehinchinensis, Pithecolobium ciyperia, and others.

2. Bamboos, composed almost entirely of clean thickets of high-stemmed bamboo—Phylostachys sp. The height of the bamboo reaches 15 to 18 m and grows in large clumps of 1.5-2 m in diameter, each of which contains from 20 to 30 stems and more. The clumps are spaced at about 5 to 10 m.

The soils in the first area are yellow earths; in the second they are red earths (red soils).

More detailed descriptions of the soils are given in our previous papers (2, 3). The differences in these soils are due to the previous activity of man, to the change in vegetation brought about by this activity.

The biogeocenose of Geronniera with ferns is almost untouched by antropogenic influences and retains its original nature.

The bamboo type is secondary. It came into being after cutting and burning of the original forests. These soils were used for agricultural crops for some time, after which they were abandoned and were overgrown with bamboo. Therefore, after deforestation, the soil was changed from yellow into red soils (1). At the present time, this soil reflects, along with other characteristics, the influence of bamboo.

Both soils are on the same elements of the relief (ancient terraces, changing into foothills). The soils are developed on the same quaternary red-colored clay loam crust of weathering (weakly lateralized). They occur at elevations of from 70-80 m above sea level.

The investigations were conducted in the forest of the biogeocenotic station of the Academy of Sciences of China which is located in the southern part of the Yunnan' Province near the boundary with Burma in the autonomous region of Sishanban.[2]

Below are given the results of a year's investigation of the water regime of the soils (from Jan. 15, 1959 to Feb. 29, 1960) to a depth of 150 cm and for individual periods up to 250 cm. To arrive at all the characteristics of the water

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[1] Field observations were made by: Kao Len, Chei-in, Chen' Shi-ven', and Van Goi-khai.

[2] The scientific direction of the soil investigations were given by the authors of this paper.

Table 1

Precipitation and air temperature under forest cover and in the open area

Determinations	1959										1960		Mean annual precipitation and temperature
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	
Geronniera Forest													
Air temperature, °C													
Mean	19,2	23,5	23,5	24,0	24,0	23,9	22,7	20,9	19,0	17,7	15,6	17,0	20,9
Maximum	28,5	31,8	28,6	27,8	27,3	26,9	25,7	24,4	23,2	21,6	20,4	22,8	—
Minimum	18,6	16,0	19,5	21,4	21,5	21,7	20,1	18,2	15,3	14,4	13,1	12,7	—
Precipitation, mm	a	a	302,6	295,1	238,0	210,9	194,6	38,5	0,2	43,6	68,2	1,7	1393,4
Open area													
Air temperature, °C													
Mean	17,4	21,5	24,0	25,0	24,8	24,6	23,3	21,5	19,5	18,2	14,5	16,0	20,8
Maximum	31,2	33,7	32,4	31,9	31,8	31,4	30,5	30,2	30,7	28,4	24,3	25,0	—
Minimum	11,4	15,3	18,9	21,3	21,6	21,4	20,1	17,8	14,6	13,7	12,1	12,7	—
Precipitation, mm	16,1	13,2	373,0	338,9	282,8	227,9	223,5	42,6	10,2	63,1	81,3	6,3	1678,9
Interception of precipitation by canopy in %	—	—	19	13	16	8	13	10	98	31	17	73	17

[a] Precipitation was not determined accurately. We assume that for the 2 months it did not exceed 1 mm since in the open only 13.1 mm and 13.2 mm fell.

Note: Comma represents decimal point.

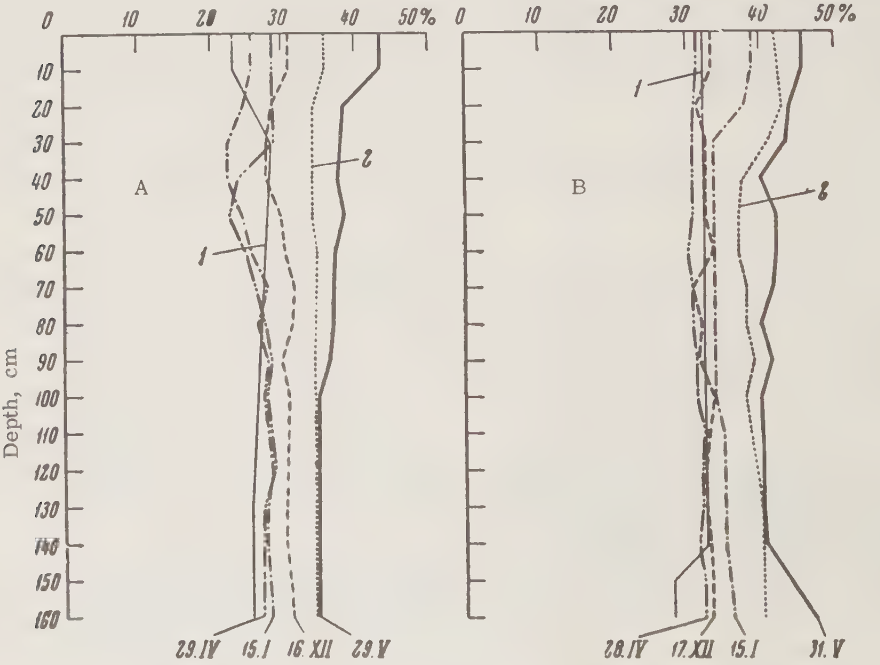

Fig. 1. - Distribution of soil moisture: A - in yellow earths of the Geronniera; B - in red earths of the bamboo biogeocenose. 1 - WM (wilting moisture); 2 - FMC (field moisture capacity)

regimes of tropical soils it is necessary to carry out long-term investigations over a great depth and to cover weather changes and weather conditions over a period of years. But considering the almost complete lack of data in the literature, our results might prove of interest insofar as they present the peculiarities of the water regime of soils by seasons and for an entire year.

At the same time, we must point out the considerable difficulties which we had in generalizing the material. We did not previously have occasion to deal with active and uninterrupted changes of the water regime of soils during an entire year and also of the full year cycle of vegetation. In this case, the notion of a clearly expressed rhythm of the water regime of soils which is characteristic of the temperate belt is inapplicable. Here, the period of the active moisture cycle is followed by a passive period which is characterized by negative temperatures, freezing of soil, and the interruption of activity of plants.

As is known, studies of water regime are conducted in the frame of the so-called hydrologic year which covers periods predominantly of accumulation and of loss of moisture. Under the climatic conditions of the tropics such periods do not appear clearly. Furthermore, here the periods of moisture accumulation in the soil coincide with that of maximum transpiration. The dry period is characterized by (continuous) uninterrupted intensive evapotranspiration from the soil.

We employed the common methods used in USSR investigations in order that the data received could be compared with similar data for other soils.

Soil samples for determination of moisture content were taken with an auger for each 10 cm layer of soil in six replicates. Drying was carried out at a temperature of 100-105°C to constant weight. Deviations of moisture in each individual sample were not allowed to exceed 2%-3%. Bulk density was determined with the aid of the Kachinski auger. The "field" or minimum water holding capacity was determined by the method of flooded quadrats. Precipitation was measured in an open area and under the Geronniera forest. The rain gages were placed on the surface of the soil which made it possible to determine the retention of precipitation by the tree canopy. The wilting moisture content was determined in containers in which clover was grown.

Moisture was computed in percent of dry weight as well as in millimeters, which made it possible to investigate not only the dynamics of wetting, but also to determine values of the water balance. The values are only approximate in as much as during the first year we could not determine the flow of moisture into the deeper horizons of the soil. Nevertheless, they do show the specific characteristics of the water regime of the soil which depends on the type and character of the vegetation.

The regime of precipitation and of air temperature over the year shows (Table 1) that the mean monthly temperature during the rainy

Table 2

Bulk density and porosity of tropical soils

Determinations	Depth, cm																		
	0—10	10—20	20—30	30—40	40—50	50—60	60—70	70—80	80—90	90—100	100—110	110—120	120—130	130—140	140—150	150—160	160—170	180—190	200—210
In the Geronniera biogeocenose																			
Bulk density	0,81	0,93	0,92	0,91	0,94	0,97	0,95	0,93	0,95	0,95	0,94	0,96	1,02	1,08	1,08	1,08	1,08	1,07	1,06
Porosity, %	69,2	65,7	66,0	67,1	66,1	65,0	65,8	66,5	65,8	65,8	65,8	67,9	66,0	60,3	60,3	60,3	60,3	60,6	61,0
In the Bamboo biogeocenose																			
Bulk density	1,06	0,95	0,96	0,94	1,01	1,04	1,07	1,02	1,04	1,05	1,12	1,00	1,03	1,05	1,06	1,11	1,17	1,19	1,18
Porosity, %	60,9	64,9	64,6	65,3	62,7	61,6	61,1	62,9	62,2	61,8	59,3	63,6	62,5	61,8	61,4	59,9	57,9	57,2	57,5

Note: Comma represents decimal point.

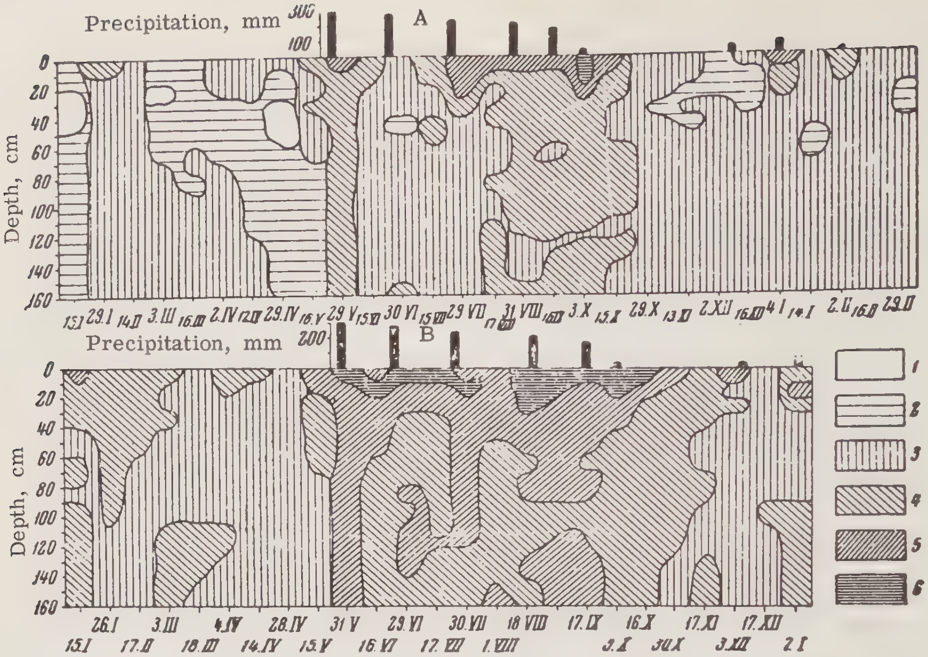

Fig. 2. - Chronoisoplets of moisture of yellow earths in the Geronniera biogeocenose: - A - chronoisoplets of moisture of red earths in the Bamboo biogeocenose - B. for 1959-1960 in % of dry soil. 1 - 23%-25%; 2 - 25%-29%; 3 - 29%-34%; 4 - 34%-39%; 5 - 39%-44%; 6 -> 44%.

season is somewhat higher in the open than under the forest cover. During the dry and foggy period it is reversed (except for individual months). This is due to the better circulation of air in the open. Mean annual temperatures were the same in both cases.

Maximum mean temperatures are considerably higher in the open area than under the forest cover. This accounts for higher evaporation of moisture from the soil surface. Minimum mean monthly temperatures under these conditions are quite close during the entire year, especially during the rainy season. Only in the dry season and in the open area, is there a tendency of lowering, which on the average does not exceed one degree. Only in March was there noted a deviation which reached 7.2°C.

All this indicates a considerably smaller effect of forest cover on the temperature regime in the tropical belt as compared with the temperate. Interception of precipitation by the tree canopy is also considerably less than in the forests of the temperate latitudes, and reaches an average of 17%. This is due to the better drainage of the moisture from the leaves of tropical trees, and to the rainfall intensity. Nevertheless, the precipitation in the open is almost 300 mm greater than under the forest cover. This indirectly supports the previously expressed idea that under tropical conditions the leaching of soils in bare areas is more intensive than under a forest cover (1).

The bulk density of tropical forest soils (Table 2) is generally low, its variations are determined by the character of the vegetation growing on them. In the yellow earths of the Geronniera biogeocenose it varies from 0.81%-0.97% to a depth of 120 cm. Only below this depth does it increase to 1.02%-1.08%. Correspondingly, the porosity of this soil is quite high. From the surface to a depth of 130 cm it varies from 69.2%-66.0%. Below this depth it decreases to 61%-60%.

In the red earths of the bamboo biogeocenose the bulk density weight is subject to large fluctuations along the profile. To a depth of 150 cm it varies from 0.94%-1.12% and only below 150 cm it is considerably more stable, ranging from 1.11%-1.19%. The porosity in the upper 1.5 m ranges from 65%-69%, and below it drops to 57%. This is due to some compaction of the soil.

The data clearly show some deterioration of the cited properties of soil under bamboo cover as compared with the Geronniera. However, both soils have a high porosity in the 2-meter depth which is due to the good state of aggregation and to sufficiently water-stable aggregates. This insures high water permeability of the soils which distinguishes them from the soils of the temperate zone. The high water-permeability of the soil is attested to by the dynamics of wetting during the rainy season (see below).

Moisture content of the soil with the Geronniera cover is 502.7 mm at field capacity and 387.3 mm at wilting. For the bamboo soils they are respectively 601.0 mm and 515.6 mm.[3] Such

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[3] Field moisture capacity and wilting moisture were determined experimentally except for field

Table 3

Soil moisture and various categories of moisture

Moisture, %	Geronniera biogeocenose		Bamboo biogeocenose	
	% of field capacity	Categories of moisture according to availability[a]		
23,0—25,0	66— 71	WM (wilting moisture)	—	
25,1—29,0	71— 83	Slightly available MBC-WM	—	
29,1—34,0	83— 97	Moderately avail. SMC-MBC	71—83	WM and slightly available
34,1—39,0	97—112	Easily available SMC-FMC	83—95	Moderately available SMC-MBC
39,1—44,0	112—126	Easily available SMC-FMC	95—107	Easily available SMC-FMC
>44	126	Excessively easily available	107	

[a] WM - wilting moisture; MBC - moisture of broken capillaries; FMC - field moisture capacity; SMC - saturated moisture-holding capacity.

Note: Comma represents decimal point.

high values of wilting moisture are due to high content of colloidal compounds of Fe and Al. This considerably affects the range of available moisture in them.

The distribution of moisture in the soil profiles during the dry season (Jan. 15, and April 28-29), at the beginning of the rainy season (May 29-31) and during the dry foggy season (Dec. 16-17) (Fig. 1) shows that under tropical conditions the soils of the Geronniera cover can be wetted during the rainy season to above field capacity over a depth of about 100 cm; and under the bamboo over a depth of 150 cm. On the contrary, during the dry season the moisture content drops below wilting moisture or close to it. Thus, in the Geronniera forest, the layer from 20 cm below the surface down to 70-80 cm is dried out. Under bamboo cover, the drying takes place from the surface down to 1.5 m. During the dry foggy season (December) which follows the rainy season, the drying of the soil under bamboo is more intensive in the entire 1.5 m depth and reaches the wilting moisture. In the soils under trees, such drying is noted only at a depth of 30-40 cm. Above and below this depth the moisture is maintained at a level considerably higher than the wilting moisture. Such distribution of moisture in soils is closely connected with the mode of root penetration into the soil and also with the differences in the rhythm of tree growth which is determined by their bioecological properties.

In the Geronniera forest the maximum number of roots is found in the layer of 0 to 30-50 cm. Below this depth the number of roots is sharply reduced, and at a depth of 70-100 cm only occasional roots are found. Under bamboo cover, the root system strongly penetrates the soil to a depth of 1.5 m. This explains the difference in the drying of the soil.

The existence of periods during which the drying of the soil is beyond the wilting moisture, leads one to suppose that the wilting moisture does not correspond to the suction force of trees. This force is probably somewhat higher than that determined experimentally. It also appears that the Geronniera and other tree species have a higher suction force than the bamboo.

Other differences are even more pronounced in the data of the annual dynamics of soil moisture (Fig. 2, A and B). These data show first of all that the principal source of moisture in the soil is precipitation. The entry of precipitation strictly follows changes in moisture content in the soil. The period of moisture accretion is very short, about one month. Only in May do the intense rains wet the soil to a depth of 1.5 m. During the rest of the rainy season, the loss of soil moisture by transpiration exceeds the supply. This is noted in the upper 30-40 cm only during short periods. In such a regime of wetting the possibility of forming perched water tables is excluded. This in spite of the heavy precipitation.

The dry season (from the end of October to May) is characterized by the prevalence of rapid evapotranspiration of soil moisture which reaches a maximum in January—April. We are inclined to relate the short-term increase in moisture in the upper 10-25 cm observed during this season to the plentiful liquid moisture condensed from the fog which occurs almost daily from 8-9 and from 11-12 o'clock in the morning. However, the quantity of water that thus reaches the soil has not been measured. Visual observations permit us to assume that this moisture has an appreciable influence on the water regime of soils and plants.

Along with common features of the water regime of the soils under the two vegetative covers, there are also differences between them. However, before we begin to discuss them, we wish to point out that the average wilting moisture for the profile of the Geronniera forest is 25.9% and of the bamboo, 33.7%. Field moisture capacities are respectively 34.9% and 40.9% (based on dry weight). Considering these indices, it must first of all be pointed out that

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moisture capacity of the soils in bamboo cover. For this soil it was assumed to be equal to the mean moisture content during the season of maximum wetting.

the greater moistening of the bamboo soils than of the Geronniera is only apparent. In spite of the higher field moisture capacity of the former, the range of active or available moisture is considerably lower than in the second. Therefore, the same gradations of moisture fluctuations expressed in the chronoisoplets do not correspond to the same values of their field capacity and express different categories of available moisture. This is seen from the following comparisons (Table 3).

The Geronniera soils, as was pointed out previously, have a larger range of available moisture than do the bamboo soils. In the latter, the accumulation of moisture above field moisture capacity is lower than in the former. Besides, it should be underscored that the values (the wilting moisture) are considerably higher than in soils of the temperate belt. This is due to the larger content of the less than 0.001 mm diameter fraction (in the first, 37%-45%; in the second, more than 45%) and the prevalence of R_2O_3 in its composition (in the first, 47%-51%; in the second, up to 50%-52%).

Considering the established gradation of available moisture, the dynamics of soil moisture under both biogeocenoses appears more clearly. In the Geronniera drying to the wilting moisture almost does not occur. It is noted only in small local spots during the period from January to April but not every year. Drying to a slightly available moisture content covers longer periods and layers of soils of different thicknesses. In individual years, such drying is noted in January and could extend to a depth of 1.5 meters or more; it is more stable from the beginning of March to the end of the dry season. Similar drying proceeds gradually with depth and in May it is abruptly replaced by wetting to field capacity and higher. However, such moisture level is maintained only during a very short period and is followed by a moderately available moisture. Such moistening during the period of August to the middle of October affects a small part of the profile at a depth from 100 to 150 cm above which and below which the moisture is considerably higher. This permits one to assume that the moisture content in this layer is close to the moisture of broken capillaries and is dominant during the greater part of the dry and dry-foggy seasons. With moisture contents close to the moisture content of broken capillaries, there appear dry spots with moisture content down to the wilting moisture in various depths. During the short rainless periods (mid-November to mid-December) such drying is noticed also on the surface. Such a mode of drying is most probably due to the non-uniform distribution of roots of different tree species.

In the bamboo soils, the period with moisture close to wilting lasts longer. It begins from the end of October and lasts until the beginning of the rainy season. Only on individual dates is there a rise in soil moisture in the upper layer from 20-100 cm up to FMC-MBC. This is connected with the occurrence of precipitation. Besides, such spotted moisture is maintained at depths of 90-150 cm which might prove its correspondence to MBC.

With the beginning of the rainy season, there is noted in this soil a short period of extreme gravitational moistening of the entire 1.5 m depth. During the subsequent period, up to the end of October, the decrease in moisture is slower than in the other soil. This could indicate that during the rainy season the evapo-transpiration of moisture by bamboo is lower than by the trees. In the dry season, the loss of moisture by evapo-transpiration under bamboo is considerably higher.

Thus, the difference in the dynamics of soil moisture in the two types is determined not only by the properties of soils—specifically by the differences in SMC-WM, but also by the composition of vegetation. Bamboo dries the soil less during the rainy season and more during the dry and dry-foggy season. In this biogeocenose the soil moisture is maintained longer on the level of WM than in the Geronniera. In the latter, the loss of soil moisture and the drying of the soil is more intensive during the rainy season and is relatively lower in the other seasons. Considering limiting values of moisture accumulation in both soils, one can assume that the maximum wetting of the soil at the beginning of the rainy season could encompass depth not greater than 2-2.5 m.[4] Also there are no conditions for the formation of a perched water table. Short term excessive wetting (higher than field capacity) is observed only in the upper 20-30 cm layer, but it quickly dissipates. More complicated is the question of the type of water regime of these soils. They do not fall in any of the types established by Rode (4). We arrive at this conclusion because the evapotranspiration from these soils lasts the entire year and the short period of leaching is limited to no more than one month and, in all probability, affects a layer of from 2-2.5 m. Therefore, to classify soils with such a regime as leached or periodically leached does not reflect their characteristics. Tentatively, we propose to call such a regime, short-term washed out, or monsoon-tropical. However, we do not insist on such designation and consider that after more information is accumulated it could be defined more precisely. Such a type of water regime will find its definite place among other types of water regimes of tropical soils.

Moisture depletion during the year is determined by the total annual precipitation minus the moisture which remains in the soil at the end of the year of observation. Such a calculation was made from January 15, 1959 to January 15, 1960. Since, from January 15 to May 1, we did not have any data on precipitation, we must tentatively accept the difference between maximum and minimum moisture content in the soil during this period as equal to the precipitation. In addition, the depletion includes also a possible quantity of moisture which penetrated below the

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[4] Data on moisture at a depth below 1.5 m showed that under the Geronniera biogeoceonoses in the layer of 150-250 cm, it ranged on April 12, 1959 between 30.8% and 32.3%; on August 17, from 33.5% - 36.3%; on October 29, from 32.2% - 33.6%; and on January 4, 1960, from 30.4% - 31.9%. In the bamboo biogeocenose at the same depth the range was: on April 14, from 31.1% to 33.0%, on July 30, from 37% to 38%, i.e., not in a single case was it greater than in the overlying layer.

Table 4

Elements of the water balance

Accretion and loss of moisture	Biogeocenoses	
	Geronniera	Bamboo
Accretion in soil from Jan. 15 to May 1, 1959	82	97
Precipitation during May 1, 1959 to Jan. 1, 1960	1393	1393
Remaining in soil on Jan. 15, 1960	53	179
Total loss	1422	1311

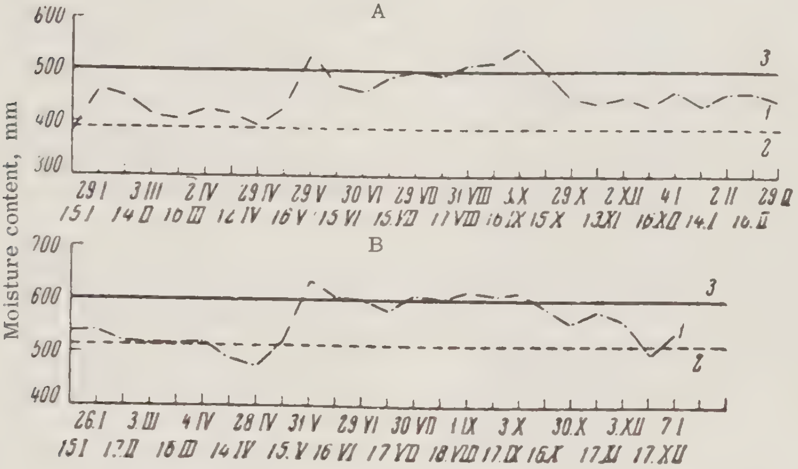

Fig. 3. - Dynamics of moisture in soils: A - Geronniera; B - Bamboo biogeocenoses; 1 - Moisture content; 2 - WM; 3 - FMC.

depth of 1.5 m. This amount is probably insignificant and is to be related only to the beginning of the rainy season. Considering the aforesaid, one can make the following approximate calculations (in mm) of the total moisture loss from the soil (Table 4).

These data stress the large total loss from both biogeocenoses. The Geronniera uses more moisture than the bamboo. As far as the moisture loss below the 1.5 m depth is concerned, it can be assumed that it does not exceed 100-150 mm considering that the moisture in the soil is present in a capillary-suspended state. Then, that part of it which penetrates below the 1.5 m layer can, during the dry period, again rise into the root zone and can be returned to the atmosphere.

The curves of the dynamics of accumulation and loss of moisture (Fig. 3) show a very narrow range of available moisture which lies between wilting moisture and field moisture capacity. In the soil with the Geronniera, it is equal to 115 mm and in the soils with the bamboo, only 87 mm. With the Geronniera, the moisture content did not fall below wilting. In the bamboo cover, this happened twice in one year, from April 4 to May 1, and in the middle of December. The lowest soil moisture was noted on April 28, when the soil lost 32 mm of moisture below the wilting. Moisture above field capacity did not exceed 29 mm under the Geronniera and 40 mm under the bamboo. This excess moisture lasted longer in the bamboo than in the Geronniera.

These are some data which characterize the water regime of forest soils developed in a tropical monsoon climate.

In conclusion, we shall dwell on some of the questions of the genesis of such soils in connection with the discovered peculiarities of their water regime.

As is known from the literature, there is an idea that the formation of these soils is connected with the prevalence in them of the downward movement of moisture which determines the sharply developed leaching type of their water regime. To this is attributed the leaching of alkali earths and alkali bases as well as SiO_2.

However, the water regime discussed previously does not indicate a possibility of elluvial leaching especially in the yellow earths of the Geronniera biogeocenose. It undoubtedly is expressed more strongly in the red earths of the bamboo biogeocenose, but here also it is limited to a layer of 30-50 cm and in this case the movement is that of R_2O_3 and not of SiO_2. Such a phenomenon may be due to the deterioration of the physical properties of the soil and to the more prolonged excessive wetting of the surface horizons. This phenomenon is not zonal, but more local as a result of the previous history of reclamation of this particular biogeocenose. Under the natural forests, such a phenomenon was not observed. On the contrary, a certain stability in the distribution of SiO_2 in the profile and an increased biogenic accumulation of other oxides in the surface horizon are pronounced. This is not in contradiction to their water regime.

There arises the question as to when and under what conditions occurs the removal of SiO_2 in tropical soils. The answer to this is hard to give. Further substantial investigations are needed. One can only express the assumption that the removal of the SiO_2 takes place at the original stages of decomposition of the parent rock up to the stage of their kaolinization. At the arrival of this stage, the quantity of SiO_2 becomes stable, which corresponds to its content of kaolin. With the interaction of vegetation with the mineral part of the soil, the soils attained stability. Also under the influence of biogenic factors there occurs in them intensive structure formation and a change in many of their other properties. This change excludes the possibility of development of an anaerobic process and of the increase in mobility of individual compounds connected with it, and therefore also their leaching and removal. Only with the disturbance of these interactions does there occur significant changes in the development of soils which are determined by changes in the mobility of mineral compounds entering into the composition of clay minerals.

In spite of the preliminary character of the expressed considerations, the cited results of the study of the water regime of soils demand reconsideration of the established ideas of the genetical nature of tropical soil formation in the monsoon climate and especially of the possibility of occurrence of lateralization and of the changes in properties of soil connected with it.

Received November 10, 1960

BIBLIOGRAPHY

1. ZONN, S. V., and LI CHEN-KVEY. 1958. Some questions of the genesis and classification of tropical soils of China. Pochvovedeniye, No. 9.

2. ZONN, S. V. 1959. Certain regularities of formation and of vertical-zonal distribution of soils in tropical and subtropical regions of Southwest China. Pochvovedeniye, No. 9.

3. ZONN, S. V., and LI CHEN-KVEY. 1960. Characterization of energetics of biological processes in tropical forest soils. Pochvovedeniye, No. 12.

4. RODE, A. A. 1956. Water regime of soils and its types. Pochvovedeniye, No. 4.

INVESTIGATIONS OF THE DYNAMICS OF WATER STABILITY OF SOIL AGGREGATES

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The Conference on Coordination of Experimental Work in the Field of Soil Physics (Leningrad, June, 1958) called the attention of investigators to the problems of formation and dynamics of soil structure and to the methods of their study. This investigation represents the first contribution to international cooperation in this field.

Soil structure is the spacial position of soil particles or more definitively, the state of aggregation of the soil. We consider the structure of the plow horizon to be optimum when rounded aggregates 0.2-5.0 mm in diameter predominate ("Mesoaggregates"—according to Kul'man [11]). These mesoaggregates must be porous, and mechanically stable and water stable. Mesoaggregates with such properties we shall call crumbs. We shall not consider deformation of mesoaggregates as the result of fragmentation (5). It should be emphasized that the processes of formation and of destruction of crumbs must be considered insofar as these opposite processes determine the dynamics of soil structure. Under dynamics we mean not only the development of the soil-forming process, but also the changes in the same soils during short periods of time.

Even field observations show that during a year the structural state of the soil changes. A comparison of data of soil samples taken at different times shows that within the experimental error the changes in these data can indicate tendencies in the development of structure. Investigations of water stability of soil aggregates (1, 6, 8, 11, 12, 20, 22, 23) showed that changes of environment lead to the changes in the tendency of the development of structure.

In undertaking investigations of the causes of changes in water stability, it is necessary to determine if the differences observed during the investigation are caused by experimental conditions. This problem is considered on several examples below (sections I and VI).

The material obtained permits the study of another problem. Comparisons of the results of investigations of the same soil material by different methods (2, 11), show statistical differences which in our opinion do not depend on the methods in the sense that we refer to. It should be realized that soil samples are heterogeneous material and that the mesoaggregates in them can differ in texture as well as in the extent to which they are affected by conditions of soil formation. One must also remember the chemical differences in the soil observed over small distances. This is roughly related to changes in biological conditions. We must also realize that particularly stable mesoaggregates are formed by the activity of microorganisms in the rhizosphere. They cannot, however, be separated and therefore in mixed samples, there are always groups of mesoaggregates which are formed in different ways. The quantitative relationships between these groups can vary.

Keeping in mind the heterogeneity of soil material, we can study the same property—water stability—by four methods of wet sieving (2). In connection with the mechanical stress used by different methods, several degrees of water stability of the sample are recognized. These correspond more or less to large heterogeneous groups of mesoaggregates. The greater the differentiation in the methods used the clearer can be established the causal dependence between conditions of structure formation and water stability.

I. Dependence of Aggregate Stability on Moisture Content of Soils

Twenty-four plots were sown to various forage crops. One plot remained bare. Perennial crops (pure stand) remained for 3 years. Annual legumes were seeded every year. The soils of the experimental area are of the loess type with a sandy loam texture formed on alluvial marl containing 6% silt and 15% of clay. The porosity of the soil is 53% (by volume), field capacity is 18% by volume. The pH of the salt extract was 6, cation exchange capacity 4.8 meq per 100 g. Carbon content 0.67%. Mean annual precipitation, 540 mm, mean annual temperature, 8.2°C.

The experiments were set up according to Muller (16). Samples from the experimental area were taken during the entire growing season (April to October). The crop rotation on the Friedrichs golf area was as follows:

Treatments

1956-clover grass mixture,	winter rye;
1957-potatoes	potatoes.

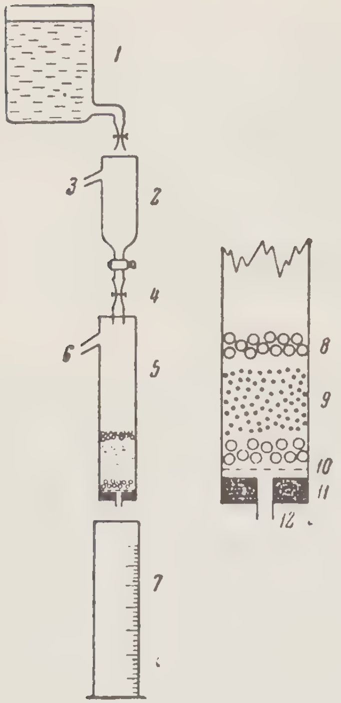


Fig. 1. - Scheme of the apparatus for measuring water stability of soil aggregates by the principle of percolation.

1 - reservoir for the water supply; 2 - vessel for equalizing pressure; 3 - overflow; 4 - rubber tube with a pinch cock for accurate regulation for the flow of water; 5 - eudiometer; 6 - overflow for the regulation of the water level; 7 - graduated cylinder; 8-12 - eudiometer enlarged; 8 - beads 4 mm in diameter; 9 - aggregates, 1-2 mm in diameter; 10 - beads 4 mm in diameter, under them a brass sieve with openings 1 mm in diameter under which is placed (not shown on the illustration) a brass ring; 11 - stopper; 12 - brass tube for the removal of water.

Fifteen samples uniformly distributed over the area were taken weekly from the 0-10 cm layer. The samples were mixed in the laboratory, the soil moisture was immediately determined, and the content of the aggregates of the soil including the 1-2 mm fraction were determined by hand sieving (the soil was not dried prior to sieving).

The water permeability of the fractions was determined. According to Sekera, Brunner (21), and also Vil'yams and Fadeyev (cited by Vorob'yev [6]), the amount of water flowing in a unit of time through a unit of area of a layer of aggregate can serve as a measure of the permeability or stability of the aggregates, provided: the hydrostatic pressure, the height of the layer of aggregates, and the kinematic viscosity are constant. The internal permeability depends only on the water stability of the aggregates. Water from a central bottle was supplied to 6 samples. The 22.5 mm diameter tubes made of plexiglass were 200 mm long. They extended from the overflow (used to regulate the water level) to the lower end which was plugged with a rubber stopper. The water was applied through a brass tube 2 mm in diameter placed in the center of the stopper. On this tube were placed an open brass ring 1 mm in diameter, a brass sieve, 60 glass beads, 25 g of aggregates with an equivalent diameter of 1-2 mm, and 40 beads of the same diameter (the aggregates were placed by weight and not according to the height of the layer. This was done assuming that in a soil of the same type, the density of aggregates is approximately the same.) The amount of water was measured in graduate cylinders (Fig. 1).

The mesoaggregates were wetted by capillary action and were covered with water (not in a vacuum!). Samples prepared in this manner in the tubes were connected to an apparatus for the determination of the quantity of water going through them in 20 minutes (ml/min). In addition the content of sand with an equivalent diameter of 1-2 mm was determined for each sample and the permeability was computed for a similar sand content. Because permeability was determined for crumbs sieved at low moisture content, the effect of pseudo-clods on these results was nil. The dynamics of the stability of the crumbs was not investigated. It was nevertheless possible to show for similar soils the increase in the stability of the structure on seeded plots as compared with unseeded. It was also possible to differentiate the effect of individual crops. The beneficial influence of some grasses and of perennial legumes on the increase of stability of structure was particularly demonstrated.

On Figure 2 are shown mean values of permeability for the 25 treatments (each point of the graph is based on 75 individual measurements) and also the variation of soil moisture with time. Except for the fifth date (Fig. 2), higher soil moisture corresponds to low permeability and vice versa. The established relation is expressed by a coefficient of correlation of 0.98. Therefore, the dynamics of filtration is determined largely by the moisture content of the soil. Kul'man and Koytssh (14) explained it by the fact that in sieving naturally wetted soil samples there appear along with true crumbs also pseudo-crumbs which are cemented by capillary forces. The number of pseudo-crumbs increases with increased soil moisture. The pseudo-crumbs fall apart when the mesoaggregates are covered with water. This reduces the permeability of the sample in conformity with the number of pseudo-crumbs in the sample. Apparently this explains the stability of crumbs in naturally wetted soils. On the other hand, changes in the stability during the growing period is only apparent.

Later, Koytssh and Kul'man (9) showed that the dependence of filtration on the original soil moisture is weakened if the formation of pseudo-crumbs is prevented by preliminary drying of the samples to a moisture content of 1%-2% before sieving. The coefficient of correlation in this case is reduced to 0.61. This somewhat reduced effect of moisture content of the sample on filtration cannot be explained by the experimental conditions. One must assume (9) that soil moisture directly or indirectly still determines the

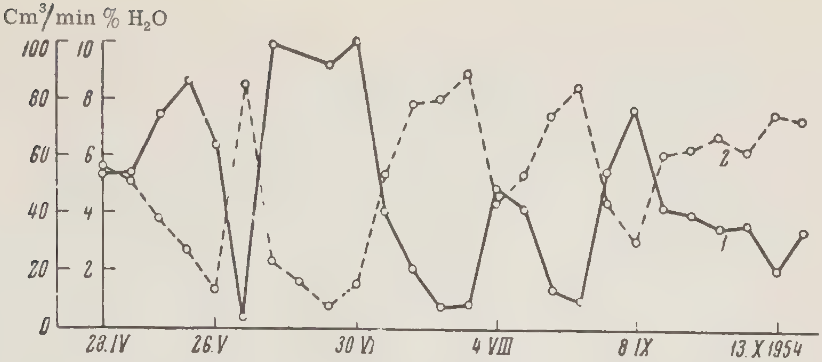


Fig. 2 - Dynamics of soil moisture and of the values of percolation for mesoaggregates with 1-2 mm in diameter obtained by sieving immediately after sampling (according to Kulman and Koytssh (14)). 1 - degree of infiltration; 2 - soil moisture in % by weight.

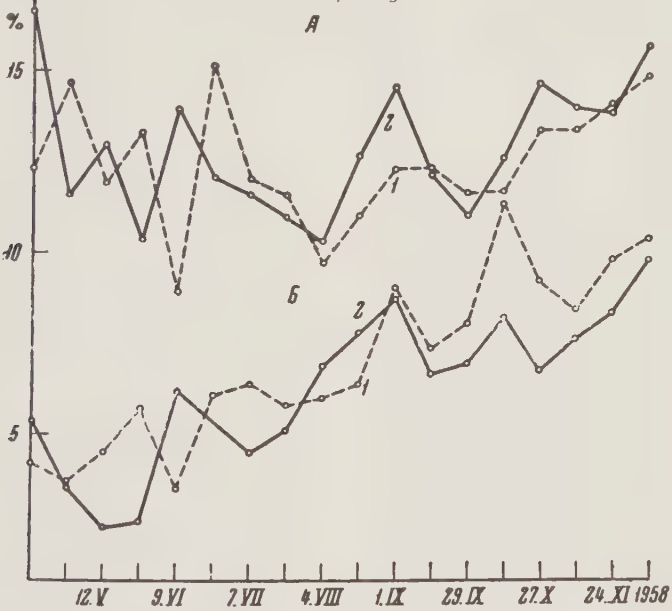


Fig. 3. - Effect of drying rate on the content of mesoaggregates 1-2 mm in diameter and on the proportion of crumbs (expressed in % by weight), determined by the method of wet sieving with the aid of a "dipping" apparatus.

Content of mesoaggregates (A) was determined on 8 replicates; proportion of crumbs (B) on 6 replicates. 1 - dried in an oven at 40° C for 90 hours; 2 - air dried for 21 days.

water stability of crumbs. Therefore, drying of the samples before sieving makes it possible to eliminate the personal errors.

II. Effect of the Drying Method and of the Length of Storage on Aggregate Stability.

The details of the drying process, including the rate, temperature, and method of drying, determine the changes in water stability which are brought about apparently by physical, chemical, and especially by biological factors. We are presenting some results of experiments carried out on an experimental area in Vollupe.

This area was sown to alfalfa and grasses. It was a gley soil formed on alluvial clay and underlain by sand. The silt content reaches 11% and the clay, 30%. Porosity of the soil is 43% by volume, field capacity, 26% by volume. pH of the salt-soil suspension is 7.2, cation exchange capacity, 22.2 meq per 100 g. Total carbon, 0.71%. Mean annual precipitation 490 mm, mean annual temperature 8.2°C.

Mixed soil samples were taken in the 0-10 cm layer at 14-day intervals during the period from April to December. A portion of the samples were immediately dried in an oven at 40°C for 90 hours to a moisture content of about 2.5%. The other portions of the samples were brought

Table 1

Effect on stability of aggregates during storage of samples prior to quick drying in the oven (90 hours at 40°C)
(Each value of mesoaggregate content was determined in three separate runs, the mean content of crumbs - in 10 replicates)

Date, 1958	Proportion of mesoaggregates			Proportion of stable crumbs		
	% of unsieved soil					
	90 hrs	21 days	49 days	90 hrs	21 days	49 days
Sept. 1	11,0	12,4	13,4	8,1	8,3	9,1
Sept. 8	11,7	15,8	14,4	6,9	11,7	9,7
Sept. 15	11,9	12,0	13,1	6,8	7,6	9,1
Sept. 22	11,5	15,7	14,0	7,6	9,1	10,3
Sept. 29	12,5	11,3	12,6	8,4	8,6	9,7
Oct. 6	11,8	13,4	14,8	8,2	9,7	11,5
Oct. 13	11,2	12,0	12,7	8,1	9,5	8,9
Oct. 20	13,8	24,2	16,4	8,1	17,5	10,5
Oct. 27	14,0	12,2	16,8	10,1	8,2	12,4
Nov. 3	12,6	15,1	18,8	9,0	10,6	12,2
Nov. 10	14,5	15,0	20,1	9,4	8,5	13,4
Nov. 17	16,3	10,9	13,1	9,5	6,9	7,8
Nov. 24	15,2	17,0	16,0	10,8	12,0	11,6
Dec. 1	13,9	15,2	17,7	10,1	10,6	13,1
Dec. 8	15,4	13,9	20,8	11,3	9,6	12,9
Dec. 15	11,6	18,7	18,0	7,2	12,9	12,4

Note: Comma represents decimal point.

to the same moisture content by slow drying in the air over a period of 3 weeks. Then soil samples of 1 kg were sieved in an electrically operated nest of sieves. After sieving, the number of aggregates of various fractions was determined. Twenty g of mesoaggregates 1-2 mm in diameter were moistened by capillarity during 5 minutes on a sieve with 1 mm openings which was previously moistened. Then wet sieving was done, the sieve was moved up and down for 20 minutes by means of an electrical arrangement. This was done under water in a vertical direction (height of rise was 50 mm, and frequency of one rise/min). The residue on the sieve was dried, weighed, and the weight expressed as % of 100 g of unsieved soil (the standard).

It can be seen from Figure 3 that the content of water-stable mesoaggregates changes during the year. Samples dried 90 hours and 21 days had the higher values. This was confirmed statistically. The same can be said about the results of wet sieving, but here there is a strong tendency for an increase of water-stable aggregates in the quickly-dried samples. A comparison of the results of drying in the air and in the oven reveals differences which are not constant either as to time or as to dimensions. The nature of the experiment did not permit us to determine the cause for this. Special investigations are required to determine whether drying produces greater stability of crumbs, and whether the stability is reduced by biological factors when samples are stored in a moist place. Only after this is cleared up can we decide to what extent an experimental set-up determines the degree of stability which more or less reflects the state of aggregation of the soil at the time of sampling. On the basis of available data, one could presume that the common quick drying is more effective for experimental purposes. This was pointed out by Russell and Tamhane (18).

The results of the experiment shown in Table 1 characterize the changes in the mesoaggregates dried for 90 hours when they are subsequently stored in air during 3 to 7 weeks. During the storage almost no moisture was absorbed from the air so that biological factors apparently did not take part in these changes. It is possible that the differences are due to physical processes or to the aging of the substances. The extent of the differences at various dates fluctuates widely. For instance, beginning on October 27, a tendency is noted of a slight weakening of the effect which determines the stability of storage for a 3-week period.

III. Relation Between Size of the Fraction and Degree of Stability

In the various experimental treatments conducted to determine the effects of various conditions on the content of crumbs, there were investigated in particular the relationship between the size of the fraction and the quantity of water-stable crumbs. To do this, samples taken in the experimental area at Vollupe (Part II) were subjected to wet sieving. Each fraction of mesoaggregates with diameters of 0.5-1.0 mm; 1.0-2.0 mm and 2.0-3.0 mm were wet sieved separately.

Figure 4 shows that over the year the 0.2-1 mm diameter fraction shows a varying content of water-stable crumbs. However, clear tendencies of these changes could not be

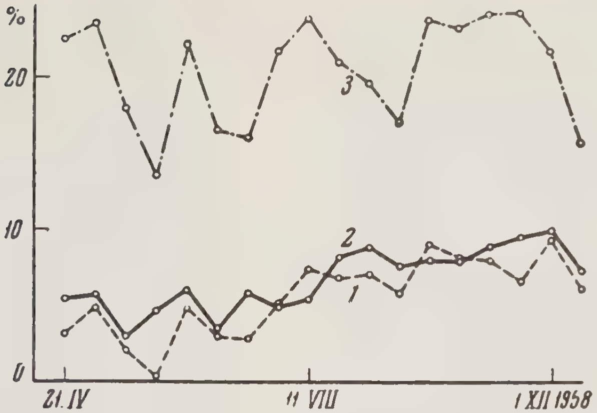


Fig. 4. - Dynamics of stability of crumbs as a function of the diameter of mesoaggregates. The proportion of crumb content was determined by the wet sieving method with the aid of a "dipping" apparatus. The proportion is shown in % of weight of unsieved soil. Determinations were replicated 6 times.

1 - 2-3 mm diameter; 2 - 1-2 mm diameter; 3 - 0.2-1 mm diameter.

ascertained. In the Spring of the year the content of the non-stable mesoaggregates in the other fractions reached 94%-98%. During the growing season, a part of this group of aggregates becomes so stable that in September the proportion of stable crumbs reaches 7%-10%. A comparison of soil samples taken at the same time would give considerably different results depending on when they were investigated. In addition, the development of the process of increasing the stability which actually was noted only in case of two fractions would remain unnoticed. One should, however, point out that the analyses of samples with the dish and the percolation method revealed other relationships also on other experimental areas.

The methods of Yoder (24), Van Bavel (4), Savinov (cited by Vorob'yev and others [3]), DeLeenheer and De Boodt (15), and others call for the study of mixed samples rather than for separate analyses of fractions in the dry state. There are no doubt reasons in favor of the use of such samples. A special advantage for instance is the planimetric treatment of the results in computing the distribution of aggregates in soil samples sieved in the dry and wet states according to Van Bavel (3). But there are also investigators who recommend studies of only one fraction. Nitzsch and Czeratzki (17), Sekera and Brunner (21), Schaller and Stockinger (19), Kul'man (11), and others consider that one or two fractions could characterize in a sufficient degree the stability of aggregates. This would save a great deal of work in comparison with study of mixed samples. Also in mixed samples, the tendency of development of stability in individual fractions is not revealed. Another disadvantage of mixed samples is that at the end of wet sieving, the residue on the sieve may consist of fragments of unstable large aggregates as well as water-stable crumbs of the particular fraction. The answer to the question as to which method is preferable will depend to a great degree on the objectives of the studies.

IV. Comparison of Two Methods of Treatment of Data of the Investigation

As is shown on Figure 5 the selection of the method of treating the data can have an effect on the interpretation of the results of the experiment. The treatment of the results of the same investigations (Part III) was done by two methods. The differences between the proportion of aggregates and proportion of crumbs (shaded areas in Fig. 5) gives an idea of the content of unstable aggregates in individual fractions. The material was also treated in accordance with the (somewhat revised) method of Van Bavel (4), Deheenheer and De Boodt (15). The results are presented in the form of a curve in the lower part of Figure 5. In accordance with the method proposed by these authors, the MWD "mean weight diameter" of the mesoaggregates was determined. For this purpose aggregates of dry and moist sieving were presented in the form of combined curves and the area between the curves was determined by planimetring. This area expressed in square mm for each date of investigation constitutes the "mean weight diameter." According to our modified methodology, the data for the three fractions are presented for the computation of the area not in the form of combined curves, but in the form of individual curves for each fraction. (Fig. 6 - see page 74). The area between the curve for mesoaggregates and the curve for crumbs corresponding to the proportion of non-water-stable aggregates is divided into two trapezoids.

The areas of both trapezoids are determined and added. The results show that the stronger the destruction of the aggregates the larger the MWD and vice versa. It follows that stability of structure varies inversely with the MD value.

If the contents of aggregates with dry and moist sieving is compared with MWD as a function of time, then for the fraction with diameter equal to MWD there will probably result a somewhat improved structural composition as in the 1-2 mm and 2-3 mm diameter fractions.

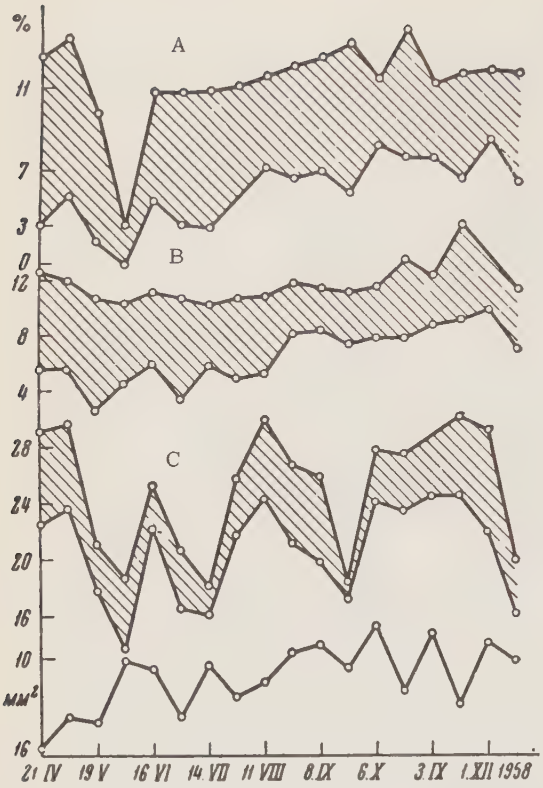
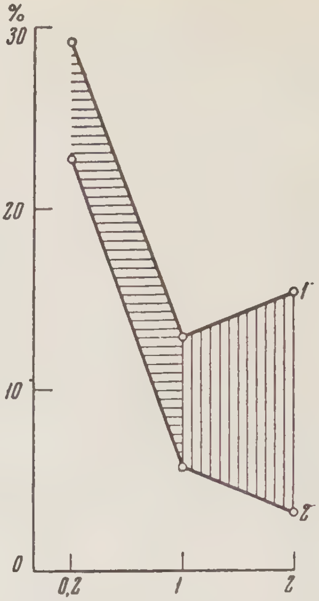


Fig. 5. - Comparison of two methods of treatment of data. The curves show changes with time of the proportion of mesoaggregates and of crumbs in three fractions (in % of weight of unsieved soil). The shaded areas give an idea on the proportion of non-water-stable mesoaggregates. The lower curve shows the "mean weight diameter" in mm^2 computed on the basis of individual determinations. A - fraction 2-3 mm in diameter; B - 1-2 mm in diameter; C - 0.2-1 mm in diameter.

Different tendencies could appear even when comparing data of two dates of observation. In two fractions it was found that the stability decreased from 19.5 to 2.6, but there was an improvement in structure, which was revealed by a lowering of MWD.

V. Relationship of the Water-stability Value to the Method Used in Measurement

Mixed samples taken from the same experimental area (Part II) were worked up and subjected to wet sieving with the apparatus previously described. Concurrently, the mesoaggregates were sieved in a moist state by means of an ultra-sonic apparatus (13). The sieves (Fig. 7) are suspended and can be immersed in water at any depth. By means of an ultra-sonic arrangement built into the bottom of the vessel, the water is subjected to oscillations with a frequency of 100 hertz. After 10 minutes the water-stable aggregate remains on the sieves. In another treatment of the experiment oscillations were transmitted also through the suspension arrangement of the sieves whereby the samples were subjected to a stronger mechanical stress.



Particle diameters, mm

Fig. 6. - An example of computing the "mean weight diameter" for the sample on April 12. The entire area of 16.45 mm^2 is divided into two trapezoids with different shading (6.80 mm^2 and 9.65 mm^2). The shaded area corresponds to the proportion of non-stable mesoaggregates. 1 - content of mesoaggregates; 2 - content of water-stable crumbs.

The three methods mentioned previously which differ in the degree of mechanical stress of aggregates under the action of water often give different indices of stability (Fig. 8). With careful use of ultra-sonic apparatus the relative proportion of water-stable crumbs constitutes approximately 75% (the relative proportion is the weight of the residue on the sieve expressed as % of 20 g of mesoaggregates weighed out for the measurement). Such treatment can be called careful because it gives identical results with the dish method of Zeller and Flunt (25). Neglecting the difference between the two dates of investigation, which is within the experimental error, the changes in water-stability could be due to meteorological and biological factors or to the processes taking place in the soil. Along with this there were observed analogous changes in stability covering several dates. The degree of stability over the entire period of investigation is quite constant. This applies also to the results obtained with the use of ultra-sonic apparatus in the second treatment when the aggregates were subjected to stronger action. With the second method it is possible to determine only 10%-20% of stable aggregates. Of special interest is the behavior of those aggregates which were obtained by means of the "dipping" apparatus. There is an increase of stability during the entire period of investigation. Apparently, with the use of the "dipping" apparatus, the aggregates

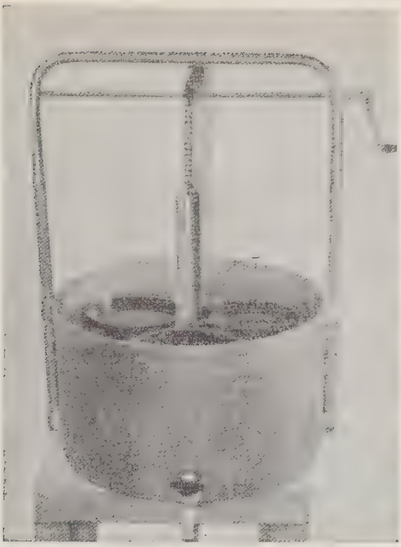


Fig. 7. - Ultra-sonic apparatus for the determination of stability of crumbs.

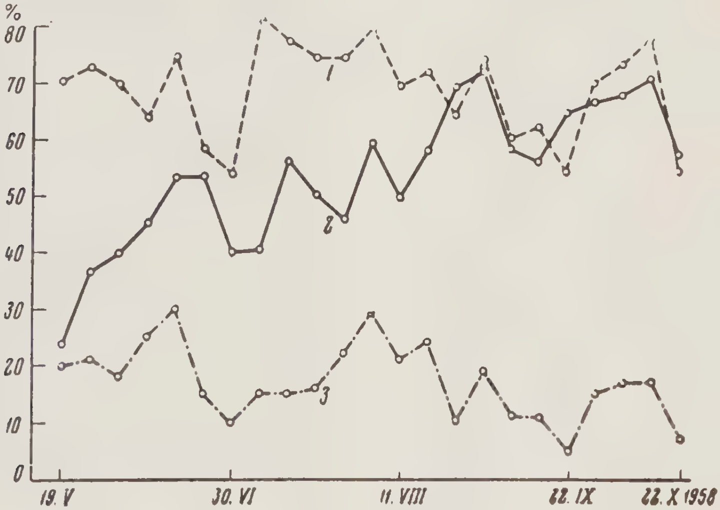


Fig. 8. - Content of crumbs (in % of weight) in samples of mesoaggregates 1-2 mm in diameter, determined by three methods. Each value was replicated six times. 1 - wet sieving (ultra-sonic apparatus— careful treatment); 2 - wet sieving ("dipping" apparatus); 3 - wet sieving (ultra-sonic apparatus— aggressive treatment).

are subjected not only to the action of water, but not withstanding the careful treatment with ultra-sonic apparatus, also to mechanical stress. About one-third of the aggregates obtained with the ultra-sonic apparatus slaked, and only at the end of the growing season did their stability gradually increase to a point that it was almost impossible to observe any difference between the results of treatment by the two methods.

Different methods always give conflicting characteristics of the experimental material. This is attested to by the analogous conclusions of Vershinin and Revut (2), although they did not consider the dynamics. Therefore, we recommend that the determination of water-stability of one and the same soil material be carried out concurrently by several methods. The experiments permit the study of the dynamics which is expressed in changes of stability of aggregates. We can determine the development of groups of aggregates. This is particularly important in the study of the causal relationship between the degree of stability and natural conditions of the territory under investigation. Results of other experiments show that some factors have an effect only on definite groups of mesoaggregates. This, however, can be proven only by means of special investigations with the careful method of treatment using only the action of water on the aggregates and avoiding concurrent mechanical influence. In this connection it is well to mention the aggressive character of Yoder's method (24) in which the frequency of vertical movement of the sieves reach 35 strokes per minute with a rise of 38 mm, or the method of Dvoracsek (7), with the horizontal displacement of the sieves 90 times per minute, and also the method of Basheyev (3) in which the sieves are tilted to a 45° angle. The effectiveness of sieving, that is the clean lines of separation of the crumbs from non-stable aggregates, strongly depends on the intensity of the movements of the sieves or water. It increases with the intensity of the movement. However, there is at the same time also an increase in the mechanical action on the aggregates, independent of the action of the water, which leads to their mechanical destruction. Therefore, it is necessary to have a combination of high effectiveness of sieving and of careful treatment.

VI. Effect of Peculiarities of the Experimental Set-up on Results on Dynamic Stability of Crumbs

To obtain information on the dynamics of

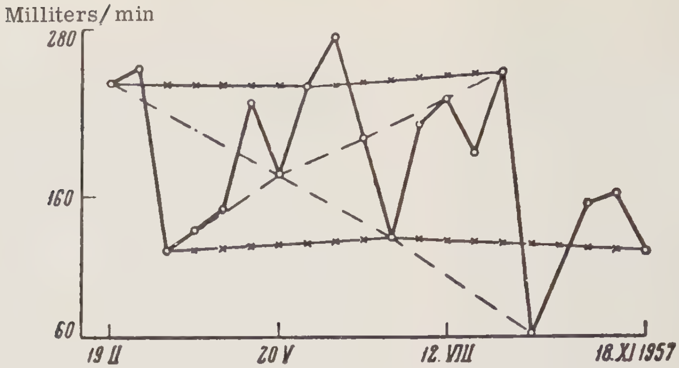


Fig. 9. - The effect of the duration of intervals between sampling dates on the interpretation of the character of change in stability of crumbs. Solid line - values of the flow in ml/min measured every 2 weeks. Arbitrarily chosen points are connected in order to illustrate the above outlined premise. Each plotted point is based on 9 replications.

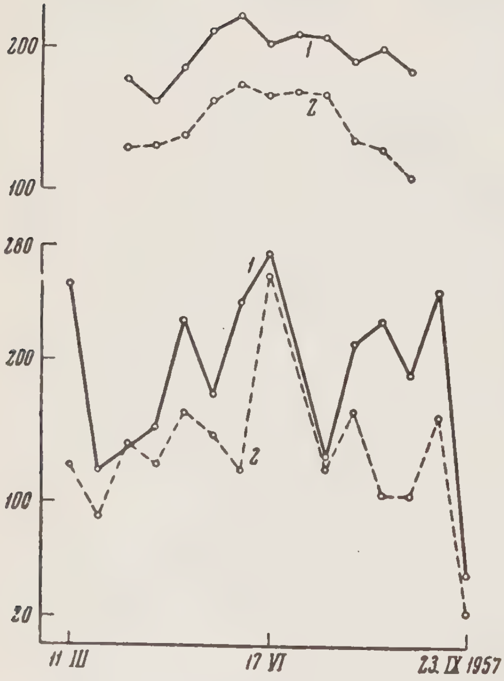


Fig. 10. - Comparison of 2 methods of treating of data to show the effect which they have on the results of measurements of the stability of crumbs in 2 experimental fields (the dynamics of stability of crumbs in this case is only of secondary interest).

A - percolation, measured at intervals of 2 weeks; B - mean values for 5 observation dates recorded at the third date. For the same crop: 1 - treatment preceded by a clover-grass mixture; 2 - treatment without a preceding crop.

stability of crumbs investigators are sometimes satisfied with 2 or 3 measurements carried out on the same area in the course of 1 year. Sometimes, however, investigations are carried out at 1 or 2 week intervals. A repetition of observation at such short intervals requires a comparatively large amount of work. Therefore, it must be determined whether it is possible to arrive at conclusions with results obtained at longer intervals of time.

For this purpose, we obtained soil samples at a depth of 0-10 cm (Part II) from the "Friedrichshoff II" experimental area (the characteristics of the soil are shown on pp. 3-4) during the period of Feb. 14-Nov. 18, 1957. The samples were taken every 2 weeks. After the samples were worked up their permeability was determined (Part I). Before measurements, these samples were moistened by capillarity in vacuum and were immersed in water in order to expel the air from the pores, since the air can have an appreciable effect on percolation. As shown in Figure 9, the value of percolation is a function of time. Individual points represent average values of 3 separate concurrent measurements for 3 plots. There are changes in stability between 2 consecutive dates. Such changes are beyond the limit of experimental error. For a 1% significance we received the value of 23.8 ml/min.

The trend of the curve indicates a rather large dynamic stability of aggregates. When samples are taken not every 2 weeks, but arbitrarily several times in the course of the year, then curves are obtained analogous to those shown for the limiting cases in Figure 9. Therefore, samples taken a few times at long intervals do not reflect the actual progress of development and may even show a reversal in its direction. The curves showing the dynamics of stability of crumbs change from year to year depending on the locality. It is therefore impossible to recommend only one method. In any event, for the territory which we investigated we recommend frequent sampling. Carrying out analyses every 8 or 12 weeks (as is suggested in the literature) appears to us to be too infrequent.

The question arises whether the results of analyses of samples taken at one time are sufficient for the purpose of comparing several treatments when the dynamics of stability of crumbs is not the principal purpose of the investigation. In Figure 10-A are compared the results of determining the stability of two treatments 1 and 2. The stability of treatment 1 clearly exceeds that of treatment 2 (each point of measurement as in Fig. 9 represents the results of 9 separate measurements). Had the treatments been investigated on the same date, it could have turned out that: April 8 would have shown a slight superiority over treatment 1 (this is not proven statistically). July 1—would have shown a slight decrease, and Aug. 26 a statistically well-supported reduction in stability, etc. Analogous data were obtained in other years on other experimental areas. Not infrequently it happens that in spite of a statistically supported average annual reduction in stability of 1 treatment, this treatment at some individual date can be superior to another treatment. It is therefore recommended to repeat observations weekly and then take the mean of 2 to 5 observation dates and make comparisons only on the basis of these mean values.

In Figure 10-B are shown averages of 5 dates of measurement presented as a mean index of the third central date of observation. A better differentiation of treatments is obtained by comparing several mean values which are varied within one date. For instance, a mixture of clover and grasses as a preceding crop is clearly superior in its effect on the state of aggregation of the area than is the treatment not preceded by grass (each point of measurement represents a mean of 45 separate determinations). Obviously the peculiarity of the experimental set-up has a determining influence on the interpretation of the results.

Received February 15, 1960

BIBLIOGRAPHY

1. VERSHININ, L. V. 1957. The problems of soil structure, in the book: Problems of Agronomic Physics (cited from A. F. Ioffe and I. I. Samoylov. Questions of agrophysics. Izd-vo VASKhNIL, Leningrad). 1957.
2. VERSHININ, P. V., and I. V. REVUT. 1952. The methodology of determining water-stability of soils, Compendium of works on agronomic physics. Agrofiz. in-t VASKhNIL, vyp. 5, Moscow—Leningrad.
3. VOROB'YEV, S. A. 1951. Manual for laboratory-practical studies in agriculture edited by M. G. Chizhevskiy, Sel'khozgiz.
4. VAN BAVEL, C. H. M. 1950. Mean weight diameter of soil aggregates as a statistical index of aggregations. Soil Sci. Soc. Amer., Proc., v. 14, pp. 20-23.
5. BAVER, L. D. 1956. Soil physics. New York, John Wiley and sons.
6. CHEPIL, W. S. 1953. Factors that influence clod structure and erodibility of soil by wind. II, Water-stable structure. Soil Sci., vol. 76:389-399.
7. DVORACSEK, M. 1953. Hidrométeres sulymérés alkapmazása és egy gépesitett megoldas a nedves szitalasos-talajszerkezetwiszgalati modoszerherz Agrokémia és Talajtan 1953, 2(4).
8. EBERT, D. 1957. Fragen der Krümelstabilität unter Berücksichtingung der Messmethodik. Z. Acker-u. Pflanzenbau, Bd. 102:391-408.
9. KOITZSCH, R., and A. KULLMANN. 1959. Zur Krümelstabilitätsmessung auf leichtem Boden (II. Mitt.) Z. Pflanzenernähr. Düng., Bodenk, Bd. 86:193-205.
10. KULLMANN, A. 1955. Beiträge zur Methodik der Krümelstabilitätsmessung auf leichten Böden. Z. landw, Versuchs- u. Untersuchungwesen, No. 1:255-270.
11. KULLMANN, A. 1958. Problematik der Krümelstabilitatsmessung und zur Methodik des Durchflusverfahrens. in Tagunsbericht Nr. 13 der Deutschen Akademie der Land-Wirtschaftswissenschaften zu Berlin, pp. 7-35.
12. KULLMANN, A. 1958. Ein methodischer Beitrag zur Stabilitätsmessung von Bodenaggregaten. Mededelingen van de Landbouwhogeschool en de opzoekingsstations van de staate Gent, Deel XXIV:341-348, No. 1.
13. KULLMANN, A. 1960. Ueber Wasserstabilitatsbestimmungen von Bodenaggregaten mit einem Schallwäscher, Z. Pflanzenernähr., Düng., Bodenk. (im Druck).
14. KULLMANN, A., and KOITZSCH. 1956. Zur Krümelstabilitätsmessung auf leichtem Boden. Z. Pflanzenernähr., Düng., Bodenk. Bd. 73:224-235.
15. DE LEENHEER, L., and DE BOODT. 1954. Discussion on the aggregate analysis of soils by wet sieving. Trans. V. Int. Congr. Soil Sci., Vol. 2:111.
16. MUELLER, G. 1954. Wechselwirkung zwischen der Anzahl der Bodenmikroorganismen und den Standartsfaktoren bei 24 Futterpflanzenarten In. Vorträge aus den Gebieten Acker- u. Pflanzenbau, Bodenkunde und Pflanzenzüchtung. Berlin. Verl. der Wissenschaften, pp. 67-89.
17. NITSCH, W., and CZERATZKI. 1940. Die Beschaffenheit und Beeinflussbarkeit der Bodenkolloide und ihre Bedeutung fuer Krümelbildung und Krümeleigenschaften Z. Bodenk. u. Pflanzenernähr., No. 18:1-50.
18. RUSSEL, E. W., and R. W. TAMHANE. 1940. The determination of the seize distribution of soil clods and crumbs. J. agric. sci. vol. 30:210-234.
19. SCHALLER, F., and K. STOCKINGER. 1954. A comparison of five methods for expressing aggregation data, Proc. Soil Sci. Soc. America, Vol. 17:310-313.

20. SCHREIBER, H. 1956. Untersuchungen über den Einflus von synthetischen Bodenverbresserrn auf verschiedene physikalische Bodeneigenschaften. Z. Acker- u. Pflanzenbau, No. 101:361-394.

21. SEKERA, R., and A. BRUNNER. 1943. Beiträge zur Methodik der Gareforschung Z. Pflanzenernähr., Düng., Bodenk. No. 29:169-212.

23. SLATER, C. S., and H. HOPP. 1951. Winter decline of soil structure in cleantilled soils. Agron. J. Vol. 43:1-4.

23. WEHRLI, A. 1958. Untersuchungen über die Wirkung von Gräsern und Leguminosen auf die Bodenstruktur. Landwirtsch. Jahrbuch der Schweiz. No. 7(6).

24. YODER, R. E. 1936. A direct method of aggregate analysis of soil and a study of the physical nature of erosion leosses. J. Amer. Soc. Agron. Vol. 28:No. 5.

25. ZELLER, A., and O. FLUNT. 1951. Zur Methodik der Messung der Stabilität von Bodenkrümeln. II. Eine Schalenmethode Veröffentlichungen der Bundesanstalt für alpine Landwirtschaft in Admont, No. 5.

SEASONAL DYNAMICS OF THE CHEMICAL COMPOSITION OF LYSIMETER WATER IN PODZOLIC FINE CLAY LOAM SOILS

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The seasonal dynamics of soil formation constitutes one of its most important indexes. During seasonal cycles the rate and direction of elementary processes change (5). Therefore, to evaluate their role in fertility, as well as to ascertain the general tendency of soil formation, it is necessary to study them over seasonal and long-term cycles.

In this paper are given the characteristics of seasonal dynamics of ionic composition of solutions of two types of podzolic soils for the period of August 1956 to January 1960.

Because the qualitative composition of solutions is determined by many factors, we must (in order to explain the results) give a short description of the set-up and conditions under which the observations were made. The methodology was described in a previous communication (6).

Objectives of the Investigation

The investigated soils are located 34 km west of Leningrad on the southeastern shore of the Gulf of Finland (the territory of the scientific base of Leningrad University). The relief is a wide, level secondary terrace with a slight slope to the north. The parent material is boulder fine clay-loam underlain with blue cambrian clay (8). The fine texture of the boulder clay loam strongly inhibits infiltration so that snow-melt and rain water remain for a long time on the surface of the soil or run off to the drainage system into the Gulf. The forest vegetation typical for this locality apparently was destroyed long ago. Up to 1955, this area was used as pasture and partly as hay land. The grass cover is predominantly *Deschampsia caespitosa*, on high spots *Polytrichum* and *Nardus stricta*. In the fall of 1955 part of the field was plowed and from then on it has been used for experimental seedings. In the spring of 1956, fertilizer was applied; 5 metric tons per hectare of slaty ash; 6 centners per hectare of ground rock phosphorus; and 2 metric tons per hectare of potassium salts. On the parts of virgin land which we shall refer to as "the meadow soil," and on the plowed portion which we shall refer to as "plowed soil," two lysimeter set-ups were installed in 1956, each consisting of three lysimeters. The distance between the installations was about 30 m.

The morphological characteristics of the

Table 1

Particle-size analyses of soils

Horizon	Depth, cm	Hygroscopic moisture, %	Diameter of fraction, mm							<0,01	Loss from HCl treatment
			1—0,5	0,5—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001		
			Meadow soil								
A_1	0—10	3,62	12,35	21,23	11,31	25,87	10,43	8,82	4,82	29,24	5,17
A_2	20—30	0,20	33,28	29,19	27,38	5,00	4,43	2,61	3,18	11,15	0,93
B	75—85	1,50	10,17	9,41	19,42	13,71	13,67	16,50	14,94	47,29	2,18
			Cultivated soil								
A_{plow}	0—10	Not det'd									
A_2	30—40	0,29	18,15	23,21	50,84	2,62	0,61	1,61	2,11	5,18	0,85
B	75—85	1,12	5,42	14,36	7,80	21,33	13,43	21,36	15,19	51,09	1,11

Note: Comma represents decimal point.

meadow are as follows:

A_1 0-18 cm. Black strongly organic (peaty), thickly permeated with thin grass roots. Occasionally, dead residues of shrub roots are found. Sharply separated from the lower horizons.

A_2 18-35 cm. Light-gray sand loam with a large number of small stones and of gravel, occasional thin grass rootlets.

A_2B 35-55 cm. Non-uniform brown clay loam with a large amount of gravel with light gray sandy streaks and spots.

B 55-85 cm. Brown clay loam with less frequent light gray streaks and ocher yellow spots, the lower boundary is not clear.

C 85-140 cm. Dove-brown fine clay loam moist and sticky with boulders and gravel.

The lysimeters were generally placed at depths of 18 cm, 35 cm, and 85 cm. On the cultivated land where the upper part of the profile was disturbed in connection with the formation of the plow horizon, the lysimeters were placed at depths of 30 cm, 40 cm, and 75 cm.

As is shown on Table 1, the texture of horizons A_1 and A_2 are coarse clay loams. The lower horizons are fine clay loams. The chemical compositions shown in Table 2 are characterized by a clearly expressed differentiation of elements in the profile. Oxides of aluminum, iron, and manganese are accumulated in the upper and lower parts of the profile. Calcium which is brought in in largest quantities in the biogenic cycles is accumulated in the organic horizon and the more mobile magnesium is leached. As a result the ratio Ca/Mg in the illuvial horizon is sharply reduced. A peculiarity of the chemical composition of the investigated soil, inherited from the parent materials, is the relatively high content of alkali reaching 4%-5%. The organic horizons have a cation adsorption capacity close to 10 meq, common for podzolic soils, which decreases to 1.5-2 meq in the eluvial horizon and is again increased in the illuvial horizon. The composition of adsorbed bases sharply changes along the profile. In the upper part calcium predominates and in the lower part magnesium. Both soils are base unsaturated and have a strong acid reaction.

Table 2

Chemical composition of investigated soils

Horizon	Depth, cm	Ignition loss	Humus, %	Total content, % of ignited soil								Adsorbed cations, meq per 100 g					pH	
				SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	Sum	$\frac{CaO}{MgO}$	Ca^{++}	Mg^{++}	H^{+}	Al^{+++}	$\frac{Ca^{++}}{Mg^{++}}$	Water	Salt
Meadow soil																		
A_1	0—10	21,34	18,0	75,06	15,80	2,13	1,56	1,08	0,43	96,08	1,46	5,65	3,39	0,21	2,87	1,66	4,70	3,70
A_2	20—30	1,52	1,28	84,25	9,80	1,56	1,25	0,81	0,03	97,70	1,54	0,16	0,78	0,04	0,79	0,20	5,23	4,27
B	75—85	4,87	0,57	72,41	16,68	4,48	0,88	1,30	0,51	96,26	0,67	3,71	5,72	0,02	0,66	0,65	5,65	3,90
Plowed soil																		
A_1	0—10	8,14	Not det'd	79,10	11,50	2,40	1,90	0,54	0,37	95,81	3,52	2,42	0,87	0,47	1,78	2,78	4,70	3,99
A_2	30—40	1,38	0,47	83,73	7,80	2,35	1,85	0,71	0,02	96,46	2,60	0,34	0,94	0,24	0,23	0,36	5,47	4,40
B	75—85	4,46	0,83	69,31	17,60	4,43	1,67	1,77	0,52	95,30	0,94	3,76	3,92	0,24	0,23	0,96	5,65	3,98

Note: Comma represents decimal point.

Meteorological Conditions and Entry of Water into the Lysimeters

Of the several factors which enter into the formation of the soil solution, the meteorological conditions, and particularly the amount of precipitation, are of primary importance. Precipitation, being the principal source of soil water, determines the dynamics of soil water in seasonal and in long-range cycles (2). However, the effectiveness of precipitation manifests itself in various ways. Depending on the relief, soil texture, depth to ground water, and on the characteristics of the vegetative cover the same amount of precipitation produces different regimes of wetting and different properties of the composition of the salt solution.

Table 3

Seasonal dynamics of meteorological conditions and entry of soil water into the lysimeters during the period Sept. 1, 1959 to Dec. 1, 1959

Horizon	Depth of the lysimeters, cm	Mean seasonal temperature precipitation and quantity of water, in mm, collected in the lysimeters			
		Spring	Summer	Fall	Winter
Air temperature[a]	Long-term mean	2,8	15,9	4,9	—6,9
	For the observation period	1,9	16,2	5,3	—4,6
Precipitation[a]	Long-term mean	107	203	158	97
	For the observation period	115	184	138	141
Meadow					
A_1	18	30,6	2,2	18,5	9,3
A_2	35	5,6	1,2	3,9	2,4
B	85	2,0	0,8	2,9	0,8
Cultivated field					
A_{plow}	30	20,6	10,6	25,7	10,3
A_2	40	21,7	7,7	39,2	9,3
B	75	22,3	10,7	48,6	10,7

[a] According to data of the Lomonosov meteorological station.

Note: Comma represents decimal point.

Meteorological conditions during the period of observation were subject to considerable changes in the annual cycle. Considering that Leningrad and vicinity has a mean annual precipitation of 565 mm (7), then the year 1957, when 629 mm fell, must be considered somewhat wet, 1958 with a total of 592 mm, close to normal, and 1959, with 519 mm, somewhat dry.

The seasonal dynamics of meteorological conditions during the period of observation (Table 3), which was in the main close to long-term average, were characterized by: greater wetness of the winter-spring period; greater dryness in the summer-fall season; cool springs and higher summer, fall, and winter temperatures.

The formation of soil water and the dynamics of its entry into the lysimeters is directly connected with the seasonal rhythm of meteorological conditions. In the spring and in the fall the soil contains gravitational moisture which forms a perched water-table and enters the lysimeters. In the winter, owing to freezing of the upper portion of the profile, and in the summer because of increased evaporation, the wetting of the soil is generally decreased. Perched water-table appears less frequently and for a shorter period. However, even in a relatively dry period, for instance, in the summer of 1959 when the mean daily temperature was 1.6°C higher and the precipitation was 50 mm less than long-term averages, the perched water-table did not entirely disappear. Thus, the investigated fine clay loam soils are subject to excess gravitational moisture forming a perched water-table during the greater part of the year. While showing a close relationship to the dynamics of meteorological conditions, soil water is dependent also on the soil properties. In the meadow soils untouched by a mechanical tillage the maximum amount of water enters from the sod horizon which has a high permeability and drains readily. Being underlain with slowly permeable horizons, the sod horizon is in a state of complete saturation in the winter and in the fall, but is subjected to greatest drying in the summer. The seasonal dynamics of wetting of this layer is clearly shown. Owing to its low permeability and slow drainage the lower part of the profile of the virgin soil is characterized by a more regular flow of solutions but in negligible amounts. Here seasonal differences in wetting are slight. The water of the lower horizons apparently plays a small part in the exchange of water between the soil and the atmosphere.

The nature and dynamics of the perched water-table in the cultivated lands is quite different. The destruction of the sod by tillage is conducive to penetration of water into the lower horizon and to its entry into the lysimeters. The seasonal differences in wetting are here equally sharply expressed over the entire profile.

Ground Water

Although the perched water-table is a product of atmospheric wetting, it is at the same time generically related to ground water (8). Inasmuch as the chemical composition of the ground water is to a large extent determined by the composition and properties of the rock, regular appearance of perched water-tables in the soil profiles presents an interest not only as an indicator of its particular water regime, but also as a quite significant factor of soil formation. It is a special manifestation of exchange of mineral substances in the system soil—parent material and underlying rock. We studied the chemical

Table 4

Chemical composition of ground water

Location and sampling date	mg per liter									In equiv-%							pH	$\frac{Ca^{++}}{Mg^{++}}$	$\frac{\text{Dry residue} + 1/2\, HCO_3^-}{\Sigma \text{ ions}}$
	Dry residue	Ca^{++}	Mg^{++}	$K^+ + Na^+$	HCO_3^-	SO_4^{--}	Cl^-	NO_3^-	Σ ions	Ca^{++}	Mg^{++}	$K^+ + Na^+$	HCO_3^-	SO_4^{--}	Cl^-	NO_3^-			
									1957										
Boring																			
Aug. 30	300,0	31,6	21,3	34,2	204,4	44,8	23,1	Not det'd	359,4	16,0	18,0	16,0	33,8	9,6	6,6	Not det'd.		1,48	1,12
Nov. 13	Not det'd	72,4	83,5	71,4	560,0	122,0	59,5	"	968,8	13,5	26,0	10,5	34,3	9,5	6,2	"	8,00	0,87	—
									1958										
Jan. 30	297,0	36,4	24,9	38,0	228,0	49,7	23,0	Not det'd	400,0	16,8	19,2	14,0	34,4	9,6	6,0	Not det'd		1,46	1,03
Feb. 16	388,0	38,0	23,0	40,0	226,0	25,0	41,8	"	393,8	17,7	17,7	14,6	34,4	4,8	10,8	Not det'd	7,20	1,66	1,27
May 23	292,0	31,2	21,0	32,0	195,0	43,6	17,5	"	340,3	17,0	19,1	13,9	34,8	9,9	5,3	"	Not det'd	1,48	1,14
Aug. 17	Not det'd	37,0	23,4	34,7	217,5	48,0	19,4	5,0	385,0	17,9	18,8	13,3	34,5	9,7	5,3	0,5	"	1,58	—
									1959										
July 4	252,0	28,2	17,1	19,0	154,0	30,0	16,1	None	264,4	19,6	19,8	10,6	35,1	8,7	6,2	None	Not det'd	1,65	1,24
									1957										
Spring in the wall of gully																			
Nov. 13	—	38,2	18,2	65,6	215,0	84,5	16,9	Not det'd	438,4	16,6	13,2	20,2	30,4	15,4	4,2	None	7,82	2,10	—
									1958										
Feb. 16	332,0	40,0	15,6	57,5	210,0	80,0	17,2	Not det'd	420,3	17,8	11,6	20,6	30,8	14,8	4,4	None	7,20	2,56	1,04
May 23	Not det'd	33,0	18,6	44,2	186,0	75,0	13,0	"	369,8	16,6	15,6	17,8	30,5	15,7	3,8	"	6,89	1,79	—

Note: Comma represents decimal point.

Table 5

Seasonal dynamics of CO_2 concentration and of non-volatile acids in lysimeter water, averages for the period of observation, meq/liter

Horizon	Lysimeter depth, cm	Mar.-May		June-Aug.		Sept.-Nov.		Dec.-Feb.		Maximum CO_2 concentration	Number of analyses
		CO_2	Non-volatile acids	CO_2	Non-volatile acids	CO_2	Non-volatile acids	CO_2	Non-volatile acids		
					Meadow soil						
A_1	18	3,65	0,00	1,44	0,00	1,09	0,09	2,41	0,00	4,75	38
A_2	35	1,83	0,01	1,74	0,00	0,79	0,09	2,45	0,00	3,76	33
B	85	0,44	0,00	0,05	0,00	0,01	0,00	0,03	0,00	2,04	38
					Cultivated soil						
A_{plow}	30	2,37	0,02	1,52	0,01	1,25	0,40	1,31	0,00	3,85	37
A_2	40	1,79	0,01	1,70	0,00	1,08	0,18	1,51	0,00	2,65	31
B	75	1,15	0,00	0,91	0,00	0,75	0,00	1,22	0,00	1,68	31

Note: Comma represents decimal point.

composition of ground water samples taken from borings 16 m deep located 1 km downhill from the lysimeter installations along the slope of the terrace. We also analyzed the water of a spring emerging from the wall of a gully which drains the territory under investigation. The results are shown in Table 4.

In this investigation we did not attempt to study the dynamics of the chemical composition of ground water and did not carry out any systematic observations in this direction, yet the data on Table 4 show that the concentration and composition of the ions in the ground water were subject to considerable fluctuation. For instance, in the wet fall of 1957, the sum of the ions in the water from the borings reached 968.8 mg/liter, in the dry summer of 1959 it fell to 264.4 mg/liter. The relative content of individual ions was apparently rather constant. Of the ions, HCO_3^- predominated in all cases; of the cations, Mg^{++} in the water of the boring, and $K^+ + Na^+$ in the spring water.

Seasonal Dynamics of Free CO_2 Concentration and of Non-Volatile Acids in Lysimeter Water

A considerable accumulation of carbon dioxide in the soil solution of coarse clay loams of the Devonian plateau during periods of intensive wetting was reported previously (7). Analogous results were obtained for the fine clay loams under investigation (Table 5). In the majority of cases all the titratable acids were due to free carbonic acid. The non-volatile acids which appeared principally in the fall period constitute a negligible part. Carbon dioxide accumulates in the soil during the entire year. However, its greatest concentration is reached in the winter and spring in the solutions which form under conditions of impeded gas exchange. The organic horizons of both soils are potentially favorable for the formation of CO_2. The intensive drying and rapid evaporation in the summer and freezing in the winter make the content of carbon dioxide during these seasons lower than in the eluvial horizons. In the lower parts of the profile, the concentration of CO_2 increases slightly only in individual periods.

Seasonal Dynamics of Concentration and Composition of Ions of Lysimeter Water

To determine the ionic composition of the solutions entering the lysimeters during the period of investigation, 72 analyses of water from the meadow and 78 from the cultivated land were made. The results of these analyses in the form of mean seasonal values are summarized in Tables 6 and 7. Grouping the data by seasons not only simplifies the presentation of the factual material, but also helps in its correct interpretation.

Seasonal Dynamics of Ionic Composition of Solutions in Sod-Podzolic Soil of the Meadow

The data shown in Table 6 quite obviously indicate that bicarbonates predominate in the salt composition of the soil water as well as of ground water. Salts of other acids including organic acids are clearly of secondary importance. The composition of the cations appears less constant. In the solution of the organic horizon calcium bicarbonate predominates. In the eluvial horizon the role of the magnesium and of alkali increases with the relatively high concentration of calcium. In the solutions of the eluvial horizon the principal components become bicarbonates of magnesium and of bases. The relative role of calcium is diminished to 3.5-7.6 equiv-percent. Consequently, in the organic horizon carbon dioxide is found in equilibrium with calcium ion according to the equation: $2CO_2 + 2H_2O \rightleftharpoons 2H^+ HCO_3 +$ (adsorbing complex) Ca $\rightleftharpoons$ (adsorbing complex) $H_2 + Ca(HCO_3)_2$. In the illuvial horizon, magnesium bicarbonate and possibly sodium bicarbonate are formed in the same way.

With the increase of P_{CO_2} in the soil air, the

Table 6

Seasonal dynamics of ion composition and concentration in lysimeter water of meadow soil

Horizon	Lysimeter depth, cm	In mg/liter									In equiv-%								pH range	$\frac{Ca^{++}}{Mg^{++}}$	$\frac{\text{Dry residue} + 1/2\ HCO_3^-}{\Sigma\ \text{ions}}$	Number of samples analyzed
		Dry residue	Ca^{++}	Mg^{++}	K^++Na^+	HCO_3^-	SO_4^{--}	Cl^-	CO_3^-	Σ ions	Ca^{++}	Mg^{++}	K^++Na^+	HCO_3^-	SO_4^{--}	Cl^-	CO_3^-	Organic acids				
Spring																						
A_1	18	323,0	38,0	10,2	3,7	151,4	11,1	3,6	—	218,0	33,5	13,8	2,7	42,5	3,7	1,8	—	1,9	5,90—6,56	3,71	1,73	5
A_2	35	446,0	25,7	10,4	22,9	155,3	20,6	2,5	—	237,4	21,4	17,8	10,8	40,5	6,8	1,7	—	1,0	5,82—6,82	2,47	2,20	5
B	85	298,7	12,3	32,1	42,3	237,7	11,5	7,8	21,4	365,1	6,5	24,7	18,8	38,0	2,4	3,5	6,1	—	8,00—9,35	0,38	1,14	7
Summer																						
A_1	18	277,0	30,0	5,1	1,9	109,0	7,0	2,2	—	155,2	36,9	10,2	2,9	47,8	0,9	1,3	—	—	5,88—6,80	5,90	2,14	2
A_2	35	257,7	14,1	11,3	22,9	136,9	13,5	4,7	—	203,4	13,5	18,4	18,1	42,5	4,9	2,6	—	—	6,70—6,95	1,25	2,36	4
B	85	443,3	13,9	23,2	45,4	225,1	11,2	7,1	12,2	338,1	7,8	21,9	20,3	40,8	2,9	2,1	4,2	—	7,70—8,70	0,60	1,64	5
Fall																						
A_1	18	328,2	18,7	9,0	6,7	71,3	26,4	7,0	—	139,1	23,6	17,8	8,6	28,9	15,0	5,8	—	0,3	5,62—7,54	2,08	2,62	15
A_2	35	476,0	21,3	13,7	20,5	151,8	25,9	5,3	—	238,5	16,8	17,9	15,3	39,3	8,4	2,3	—	—	6,70—7,97	1,56	2,31	7
B	85	431,6	10,5	41,5	51,1	291,0	18,2	5,5	23,7	441,5	4,5	28,4	17,0	39,7	3,3	1,3	5,7	—	8,00—9,50	0,25	1,30	9
Winter																						
A_1	18	297,0	22,0	11,6	5,8	102,7	21,4	4,8	—	168,3	21,9	21,5	6,6	32,0	12,6	5,0	—	0,4	6,20—6,50	1,90	2,07	6
A_2	35	299,0	39,0	21,4	6,8	205,7	18,3	3,6	—	294,8	24,7	21,9	3,4	41,9	4,7	1,5	—	1,9	6,67—7,00	1,83	1,36	4
B	85	Not det	6,3	44,2	45,5	275,2	13,6	4,0	31,7	419,5	3,5	30,3	16,2	38,4	2,7	1,1	7,8	—	9,00—9,15	0,14	—	4

Note: Comma represents decimal point.

Table 7

Seasonal dynamics of ion composition and concentration in lysimeter water of cultivated soil

Horizon	Lysimeter depth, cm	In mg/liter									In equiv-%								pH range	$\frac{Ca^{++}}{Mg^{++}}$	$\frac{\text{Dry residue} + 1/2\ HCO_3^-}{\Sigma\ \text{ions}}$	Number of samples analyzed
		Dry residue	Ca^{++}	Mg^{++}	$K^+ + Na^+$	HCO_3^-	SO_4^{--}	Cl^-	NO_3^-	Σ ions	Ca^{++}	Mg^{++}	$K^+ + Na^+$	HCO_3^-	SO_4^{--}	Cl^-	NO_3^-	Organic acids				
											Spring											
A_{plow}	30	693,1	32,7	13,1	21,4	102,8	41,8	34,1	4,1	250	23,2	15,2	11,6	23,6	12,0	13,2	1,1	0,1	5,81—6,31	2,50	2,97	6
A_2	40	552,0	28,1	14,0	19,3	92,1	35,5	30,7	5,2	224,9	21,6	18,4	10,0	22,6	12,0	13,8	1,6	None	5,90—6,36	2,00	2,66	6
B	75	741,0	29,1	16,9	23,1	132,2	33,1	22,9	0,5	257,8	19,4	18,8	11,8	31,9	9,4	8,6	0,1	"	6,16—6,72	1,72	3,10	6
											Summer											
A_{plow}	30	585,5	26,9	14,9	18,5	66,4	29,7	30,8	14,9	202,1	18,9	19,4	11,7	18,0	14,9	13,8	3,3	"	5,80—7,48	1,80	3,40	6
A_2	40	428,3	27,3	9,3	27,6	86,0	36,4	28,8	18,0	233,4	18,9	14,0	17,1	20,3	12,8	13,4	3,5	"	5,87—6,38	2,94	2,02	3
B	75	233,0	18,3	10,9	21,9	97,8	23,2	20,7	1,3	194,0	16,6	17,2	16,2	29,5	9,1	11,0	0,4	"	6,30—6,48	1,68	1,46	3
											Fall											
A_{plow}	30	392,0	31,0	16,5	13,4	45,6	38,1	36,4	42,4	223,4	23,6	21,2	5,2	11,4	12,2	15,8	10,6	"	5,98—7,10	1,88	—	10
A_2	40	305,0	23,0	14,2	17,6	46,4	45,3	31,1	26,8	204,4	19,2	19,6	11,2	12,9	15,7	14,5	6,9	"	5,45—7,10	1,62	1,61	13
B	75	587,5	21,5	17,7	18,1	76,9	28,5	27,8	37,5	228,0	16,4	22,6	11,0	18,5	9,3	12,7	9,5	"	6,20—7,30	1,22	2,74	14
											Winter											
A_{plow}	30	493,0	28,2	12,7	27,2	81,1	39,5	35,6	25,6	249,9	22,2	15,6	12,2	18,4	12,6	14,5	4,5	"	6,08—7,22	2,22	2,14	4
A_2	40	533,0	23,6	12,9	13,0	79,5	30,0	30,2	Not det'd	—	21,4	19,2	9,4	23,5	11,1	15,4	—	"	5,87—6,06	1,83	—	2
B	75	636,0	29,8	19,9	28,7	63,3	29,4	26,3	17,3	294,7	17,1	18,8	14,1	27,9	7,9	9,4	4,8	"	6,55—6,70	1,50	2,44	5

Note: Comma represents decimal point.

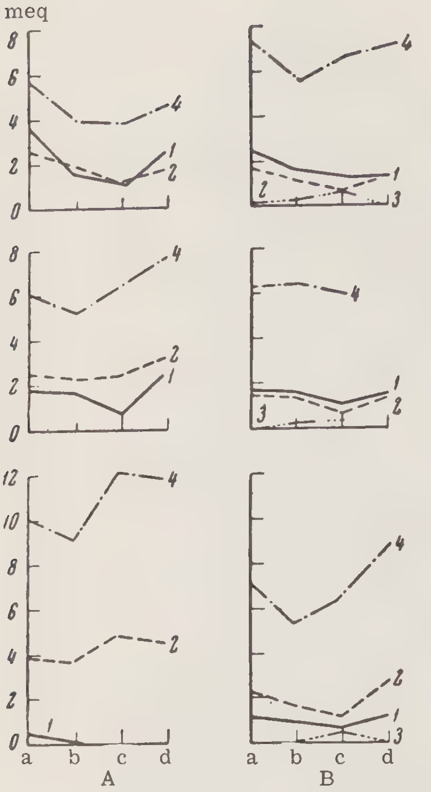

Fig. 1. - Seasonal dynamics of concentration of CO_2, HCO_3^-, NO_3^-, and of the sum of ions in lysimeter water from August, 1956– Dec. 1959.

A - meadow soil; B - cultivated soil. 1 - CO_2; 2 - HCO_3^-; 3 - NO_3^-; 4 - sum of ions. a - spring; b - summer; c - fall; d - winter.

reaction goes to the right. The limiting factor can be only the presence of bases to combine with CO_2. First, there is a mobilization of the bases from the adsorption complex, but with insufficient bases the sesquioxides are apparently also changed into mobile form. Moreover, the formation of carbon dioxide is accompanied by a decrease in free oxygen and by the transformation of the oxides into more mobile oxide forms.

With a decrease in P_{CO_2} carbon dioxide equilibrium is shifted to the left and in this case, the bases return to their original state and release carbon dioxide into the water. After complete saturation of the soil adsorption complex bicarbonate salts drop out and normal carbonates are formed. When the solutions enter into the lysimeters in which P_{CO_2} is appreciably less than in the soil, the carbonic acid equilibrium also shifts to the left. However, owing to the absence of one of the most important components of the natural system—the soil adsorption complex, the decomposition of bicarbonates is accompanied by the formation of normal carbonates. In the more dilute solutions of the upper horizons with relatively high content of calcium, this shifting appears considerably weaker and the reaction of the solution remains weakly acid or neutral. On the other hand, in the solution of the illuvial horizon where the concentration is considerably higher and magnesium ions and bases predominate, the shifting of the carbonate equilibrium (as is indicated in Table 6) is accompanied by the appearance of CO_3^{--} and by a sharp rise in the value of pH.

The high value of alkaline solutions which enter from the illuvial horizon rich in magnesium, is analogous to that observed by Morozov (2) in his experiments on the action of water saturated with carbonic acid on rocks and minerals. After 12-days saturation with carbonic acid, and consequent 4-day settling, the solution which came into equilibrium with the atmospheric CO_2 had in all cases an alkaline reaction. In the experiment with the fluoric magnesium mica (phlogopite) the pH was raised to 10.8.

Therefore, the commonly high alkalinity of solutions entering from the illuvial horizon of acid podzolic soils is due to the production of P_{CO_2} when the solution enters into the collector of the lysimeter, and to the shifting of the carbon dioxide equilibrium to the left on the one hand, and to high content of magnesium and of bases in the solution itself, on the other hand.

Closely related to this equilibrium and to the concentration of free CO_2 are the seasonal dynamics of the ionic concentration of solutions in the organic and eluvial horizons. The concomitant character of the changes in concentrations of CO_2, HCO_3^-, and of the sum of ions is shown in Figure 1-A. Their increase in the winter-spring period and decrease in the summer and fall, almost fully coincides. The meaning of this coincidence is quite clear. With the increase of P_{CO_2} there takes place a mobilization of the bases and the formation of bicarbonates. As a result the total concentration of ions is increased. Seasonal changes of the value of the latter are quite clearly apparent in the illuvial horizon. In the summer as a result of reduction in partial pressure of CO_2 in soil air, the concentration of Mg^{++} and HCO_3^- and the sum of the ions are reduced to a minimum. They reach a maximum in the fall and in the winter. It is quite significant that the composition of the ions not only does not change in the direction of enrichment with calcium which one would expect as a result of percolation of the solution from the top, but on the contrary the content of this ion in the fall-winter solutions is decreased absolutely and especially relatively. The concentration of the magnesium, on the other hand, increases in comparison within the summer solutions almost two fold. It follows that the fall-winter increase of concentration of ions takes place principally at the expense of their mobilization in the illuvial horizon itself.

In addition to ions, soil water always contains some weakly dissociated organic matter, colloids, and suspended matter. Some idea of their content is given by the size of the dry residue ($+ 1/2\ HCO_3^-$) and its ratio to the sum of ions. In the organic horizon the organic materials constitute an appreciable part, in the lower horizon mineral suspensions predominate. Their entry into the solution is apparently due to the disturbance of the physical state of the profile, and the formation of non-capillary spaces. Therefore, it is especially great soon after the installation of the lysimeters.

Seasonal Dynamics of Ion Composition and Concentration in Water from Lysimeters of Cultivated Land

Mechanical tillage, which sharply changed the physical state and properties of the soil by increasing the intensity of moisture and gas exchange, aided the development of biological processes, the decomposition of the sod, and together with the action of applied fertilizer brought about significant changes in the ionic composition and in the concentration of the solutions which enter the lysimeters (Table 7).

The solution of the cultivated soil is differentiated very slightly by horizons. The total of ions in the entire profile fluctuates in the range of 200-250 mg/liter. In connection with the decrease in the P_{CO_2}, the concentration of the HCO_3^- is reduced at least 2 or 3 fold in comparison with that of the solution of the virgin land. The content of chlorides and sulfates has increased especially in the upper horizon. Nitrates appear, and in the first samples taken, after 1 year of fallow of the sod in the fall of 1956, the concentration of the NO_3^- reached 265 and even 417/mg/liter.[1] In the winter the concentration of the NO_3^- decreased to 91.2 mg/liter. In the 1957 spring samples, the nitrates disappeared entirely as a result of leaching and of the development of anaerobic processes; in subsequent periods, they were entering in a considerably reduced quantity seldom exceeding 20-30 mg/liter.

Directly connected with the development of these basic processes of soil formation of oxidation of carbon and nitrogen organic compounds is the concentration of calcium, magnesium, and of other bases. In individual samples with high contents of nitrates the concentration of calcium reached 100-150 mg/liter. As a result of the intensive mineralization of the sod, the ionic concentration of the solution of the cultivated horizon considerably exceeded that of the sod horizon of the virgin land. This increase, was of course, also due to the action of the applied fertilizer, but considering the small amounts, one can assume that this action which stimulates the microbiological processes was largely indirect.

The total ions in the solution of the lower horizon is from 1 1/2 to 2 times less than in the solutions from the virgin soil. The reduction in the ionic concentrations takes place principally at the expense of bicarbonates. However, in spite of the considerable reduction of their absolute content, their relative part in the salt content of the solution of cultivated land is of primary importance and determines the seasonal dynamics of the total concentration of ions. As the data in Table 7 and Figure 1-B show, the solutions which are formed in the winter and in the spring under the conditions of impeded gas exchange, are distinguished by: higher content of bicarbonates, a wider Ca/Mg ratio, and an increased total ionic concentration. In the summer and especially in the fall, the content of bicarbonate salts in the solution is reduced, nitrates accumulate and the Ca^{++}/Mg^{++} ratio and total concentration of ions are reduced. Thus, the accumulation of nitrates although it smooths out the summer-fall depression of the concentration of ions in cultivated land, does not change the general character of its seasonal dynamics which is determined by the partial pressure of CO_2 and by the accumulation of bicarbonate salts in the soil solution.

Conclusions

1. The entry and qualitative composition of water from lysimeters depends on the one hand on the seasonal meteorological conditions, and on the other, on the physical state and chemical composition of the parent material and of underlying strata, and reflects seasonal rhythmicity of soil formation.

2. On fine-textured soils the seasonal differences appear much more pronounced. During the wet periods in the soil a gravitational perched water-table appears which moves under the action of gravity and freely enters the lysimeters. During dry periods the perched water-table occurs less frequently and over a shorter period of time. Aeration and oxidation processes increase.

3. Closely related to the seasonal differences of wetting and gas exchange, which determined the rate and direction of biological process, is the system of carbon dioxide equilibrium; $CO_2 + H_2O \rightleftharpoons H\,HCO_3 + M$ (the adsorption complex) $\rightleftharpoons M\,HCO_3 +$ (adsorption complex) H. During the winter-spring period, and in the lower horizons also in the fall, this equilibrium shifts to the right; in the summer and in the fall to the left. The seasonal rhythmicity of the carbon dioxide equilibrium appears more clearly in the virgin soil under meadow.

4. Water from the lysimeter of cultivated land formed under conditions of intensive summer gas exchange differs by considerable accumulation of nitrates and the reduction of content of carbon dioxide and of bicarbonates. Ionic concentration of solutions of the cultivated layer considerably exceeds that of the sod horizon of virgin land. In view of the more intensive aeration in the lower parts of the profile of cultivated land, the sum of the ions in it is greater than in the virgin soil.

5. The compositions of cations in the soil solution of virgin soil correspond to their composition in the soil adsorption complex. In the organic horizon they are represented primarily by calcium; in the illuvial horizon by magnesium. In the solutions of plowed soils the differentiation of the composition of cations along the profile becomes less pronounced. But even here the relative role of calcium in the salt solution reduces with depth; the role of magnesium and of alkali increases.

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[1] Unfortunately, because of insufficient volume, these samples were not subjected to a complete analysis and therefore are not included in the computations of the mean values shown in Table 7.

6. The pH of the solutions entering the lysimeters is always considerably higher than of the soil suspension. This is due to the loss of free CO_2. In the upper horizons where calcium ion is the principal constituent in the system of the carbonate equilibrium, the shift in the reaction is usually up to pH 7-8. In the solutions of the illuvial horizon of virgin soil where the Ca^{++}: Mg^{++} ratio is small, this shift, caused by the formation of $MgCO_3$ reaches pH 9.0-9.5.

7. Mechanical tillage of the soil by facilitating the penetration of moisture into the lower horizon during the winter-spring period and aeration during the summer-fall period, stimulates exchange of matter and energy in the atmosphere-soil-parent material and underlying rock system.

Received May 3, 1960

BIBLIOGRAPHY

1. VASIL'YEV, I. S. 1950. Water regime of podzolic soils. Tr. Pochv. in-ta Akad. Nauk SSSR, Vol. 32.

2. MOROZOV, S. S. 1957. Changes in the chemical composition, and in the physical and physical-chemical properties of magmatic rocks and minerals under the influence of interaction with water solutions. Compendium "Solution and leaching of rocks", Gos. izd. liter. po stroitel'stvu i arkhitekture, Moscow.

3. POKROVSKAYA, T. V. 1957. Climate of Leningrad. Gidromegizdat.

4. RODE, A. A. 1950. Regime of soil-ground water of podzol, and bog-podzol of the bog-soils. Tr. Pochv. in-ta Akad. Nauk SSSR, Vol. 32. Moscow—Leningrad.

5. RODE, A. A. 1955. Soil Science, Goslesbumizdat.

6. SHILOVA, YE. I. 1955. Method of obtaining soil solutions under natural conditions. Pochvovedeniye, No. 11.

7. SHILOVA, YE. I., and K. G. KREYYER. 1957. Carbon dioxide of the soil solution and its role in soil formation. Pochvovedeniye, No. 7.

8. YANISHEVSKIY, M. E. 1922. The vicinity of Peterhof. First All-Russian Geological Conference. Putevoidtel' geologich. ekskursiy.

WATER REGIME OF PEAT SOILS IN SUMMER UNDER CONDITIONS OF THE MESHCHERSK LOWLANDS

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Under the influence of drainage, the water regime of bogs and the direction and rate of soil-formation processes are changed. According to Rode's classification (18), drained bogs are classified as the "semi-bog subgroup" of water regime. Rode describes this subgroup in the following way: "Fed by ground-atmospheric water with or without addition of surface water. Thorough wetting several times during the year. Surface run-off almost continuously. Continuous capillary wetting of the soil profile." The limits of range in moisture are: in the upper half of the profile from saturated moisture capacity (SMC) to moisture of broken capillaries (MBC); in the lower part of the horizon from saturated moisture capacity (SMC) to field moisture capacity (FMC).

Within this large sub-group several subdivisions can be set up based on the depth to which the ground-water level is lowered. This depth has a decided effect on the water regime of the soil layer and as correctly pointed out by Skrynnikova (20) also on the soil-forming process and especially on the biochemical processes.

The recent intensification of drainage of bogs makes the study of the water regime of drained bog soil one of primary importance. Aver'yanov (1) suggests that the water regime of drained soils should be an independent object of investigation.

Below we present results of observations carried out by us from 1958-1960 on bogs with various degrees of drainage under conditions of Meshchersk lowlands.

The founder of the science of soil reclamation, A. N. Kostyakov (15), considered reclamation to be one of the most powerful means of changing and regulating the soil-formation processes (its direction and rate).

Maximum yield of agricultural crops is possible only when conditions which are most conducive to the development of plants exists. Of these conditions, the most important is the optimum relationship between moisture and aeration in the root zone. Lebedevich (16), after summarizing the materials on crop yield under conditions of Belorussian Soviet Socialist Republics, determined the following moisture levels in peat soils (in % of saturated moisture capacity) as the most favorable for the development of plants during the entire growing season; for grasses, 80%; for grain, 70%-80%; for vegetables, 60%-70%. These percentages are assured by a depth to ground water (normal drainage) ranging from 70 to 100 cm. Skrynnikova arrived at the conclusion that the most favorable type of biochemical processes which assure progressive increase in productivity of soils is created when ground water stands at a depth of 80-100 cm, i. e., close to those recommended on the basis of requirements of crops in relation to the water regime. However, maintaining ground water at the levels indicated during the growing seasons is a complicated and expensive task. Therefore, the simple and inexpensive method of drainage by means of deep canals which eliminates poor drainage (the principal fault of the older systems) appears quite tempting. It is clear, however, that with this practice the level of ground water in the summer period drops below the levels indicated above.

The required depth to ground water could be determined by means of economic computations for the individual natural zones of the USSR. At the present time, it is not possible to make such calculations because the water regime for various intensities of drainage has not been sufficiently studied. Recent literature contains many references to the effect that on areas with deep ground water, crop yields are greater than on areas with a shallow drainage net.

Characteristics of the Experimental Area, Meteorological Conditions During the Observation Period, and Methodology

Investigations were carried out on the bogs of Zabor'ye village, (the Dobrolyubov and Kal'sk "urochische"), 30 km north of the city of Ryazan'. The bogs were drained in 1953-1954 by a network of canals of various depths. The peat in the bogs is of the alder, birch type with a mixture of reeds and sedges; its thickness is about 1-3 m; it is underlain by fine-grained sand. The degree of decomposition of the organic matter is 40%-50%. Bulk density of the peat ranges from 0.24-0.38 in the upper horizons, to 0.12-0.23 at a depth of 1 m. The density is on the average 1.6-1.9, the porosity about 90%. At a depth of 40-70 cm and below, there occur local layers of beraunite with a

Table 1

Mean monthly air temperatures and monthly precipitation for the years observed

Meteorological data	Months				
	May	June	July	Aug.	Sept.
Air temperature, 1958	13,0	15,0	18,7	15,8	9,1
Same 1959	12,5	17,1	21,2	17,0	8,5
Same long-term average	13,0	16,7	19,1	17,3	11,6
Precipitation 1958	82,3	58,5	21,9	159,9	49,7
Same 1959	34,8	54,7	39,6	33,6	70,4
Same long-term average	37	52	64	59	38

Remarks: long-term average values according to data of Zverkov (10), temperature for 54 years, precipitation for 44 years.

Note: Comma represents decimal point.

thickness up to 10 cm and a bulk density of about 0.45. Total height of capillary rise in the peat determined from a curve of moisture distribution with capillary saturation is 2.0 m (observation points 1, 2, 3, 4, 5, and 10) and 2.5 m in the central part of the bog (points 6, 7, 8, 9).[1]

The meteorological conditions during the period of observation based on data of the Ryazan' meteorological station are shown in Table 1.

The 1958 growing season was cooler but better supplied with precipitation than the following year. The longest rainless periods (precipitation less than 2 mm per day) on the bog were: 1958 — May 19-30; June 20-24; June 28 — July 21; Aug. 6-10; 1959 — May 23 - June 14; June 20 - July 6; July 11-15; July 18-30; Aug. 1-7; Aug. 11-19 of 1958. The heaviest rain of 74 mm occurred on Aug. 28, 1958. The remaining rains did not exceed 25 mm per day. The ineffective precipitation (intensity less than 2 mm per day) constituted 7.5% of the total amount for the period of May to September.

Precipitation on the bog was measured by means of two rain gauges at a height of 2 m and on the surface of the soil. Soil moisture was determined gravimetrically. Samples for determination of soil moisture were taken in the half meter layer every 10 cm in 4 replicates. Lower down to the ground-water level, samples were taken at each 10 to 25 cm and were replicated 2 to 4 times. Observations were carried out at 10 locations with varying depths to ground water. The maximum distance between points of observation was less than 1 km. The frequency of observations of moisture was different at different points and ranged from 2 to 6 times per month. Bulk and particle densities of peat were determined at each point for each horizon replicated 2 to 10 times. Saturated moisture capacity was determined at all points by saturating monoliths 10 cm high. At two locations monoliths 10-120 cm high were used. The ground-water elevation was read in observation wells sunk at points of observation of moisture; readings were made at the same time as the moisture samples were taken and at other times so that all together there were not less than 4 readings per month. Evaporation from the surface of the soil and total evaporation were measured on 2 plots (at soil moisture sampling stations 1 and 8), by means of GGI 500 and Popov evaporimeters in 1959-1960, and only with the latter in 1958. The GGI 500 evaporimeter was weighed every 5 days, the Popov every 1-3 days. The monoliths were changed every 10-15 and every 3-5 days respectively. Altogether in 1958, observations were made with 4 evaporimeters and in 1959 with 8. Total evaporation was determined for sunflower and potatoes; the measured values were adjusted to field conditions in accordance with existing methodology.

Dynamics of Soil Moisture

Moisture in peat soils during the growing season depends on: the depth to ground water; water properties of the soil; amount of precipitation, evaporativity crops, etc. Along with changes in soil moisture the aeration also changes. The aeration can be determined as the difference between saturated moisture capacity and actual moisture content of the soil.

An analysis of the data showed that there is a clearly expressed relationship between the depth of ground water and soil moisture. This relationship is different in different periods of the year. During the wet periods (fall and summer raining periods) the relationship between moisture and depth of ground water has a clearly expressed parabolic character (Fig. 1, 1). This is well expressed by Aver'yanov's equation

$$W_y = W_1 \sqrt{1 - \frac{y}{H_k} - \left(\frac{W_0}{W_1}\right)^2},$$

W_y is the moisture at the height "y" above the ground water; W_1 — saturated moisture capacity near the surface of the ground water, W_0 is the moisture content at the maximum height of capillary rise H_k. This formula as far as we

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[1] In this case we considered not only the moisture that rose by capillary action, but also the perched capillary moisture.

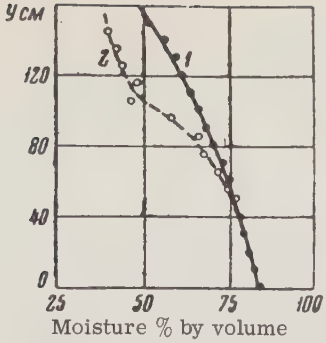

Fig. 1. - Typical soil moisture curves.
1 - with capillary saturation;
2 - during the dry period Aug. 1, 1959.

Table 2

Measured and computed (by formula) values of moisture (% by volume) at selected horizon above the level of ground water (Y)

Indices of moisture	Moisture at height Y, cm											
	0	10	30	50	70	90	100	120	140	160	180	190
Actual	83,3	81,4	78,5	76,3	73,0	67,7	65,7	61,2	55,9	48,6	42,5	40,5
Computed	83,3	81,6	78,2	74,6	70,8	66,9	64,5	60,0	55,2	50,0	44,2	41,

Note: Comma represents decimal point.

know was not checked on peat soils (2). Good results are obtained by a simplified formula

$$W_y = W\sqrt{1 - \frac{y}{H_k}},$$

Where W is the moisture content at the ground water surface. In Table 2 are shown the values of soil moisture (obtained by averaging 25 observations during the moist period) measured at points with H_k = 2.5 m and computed by the simplified formula.

The root mean square deviation of the computed values from the actual for the 2 m thickness of the peat (20 horizons) was 1.45%, which is quite small. Points at which the maximum height of the capillary rise was 2 m, showed analogous results.

It thus appears that with Aver'yanov's formula it is possible to determine with a high degree of accuracy the distribution of moisture in the soil above the ground-water level as a function of the capillary properties of the soil and of the depth of ground water, and therefore, also to compute by integration the moisture content corresponding to field moisture capacity (FMC).

Some limiting moisture content in the active layer of soil for points with H_k = 2.5 m are shown in Table 3.

The amount of available moisture is computed as the difference between the quantities corresponding to FMC (field moisture capacity) and WM (wilting moisture). The latter is taken to be 28% of the saturated moisture capacity of peat on the basis of average values of WM determined for bogs with similar moisture properties by other investigators (4, 9, 14, 19). It should be pointed out that the use of data on critical moisture published lately (4, 9) is difficult because the moisture is expressed in % by weight and the characteristics of the peat are not fully given.

As is seen from Table 3 the amount of available moisture even in the case of maximum saturation of the active 0-80 cm layer of the soil with deep lying ground water is not great. The development of crops under these conditions is therefore determined entirely by the quantity and time distribution of precipitation and by the rate of subsurface flow from ground water.

It can be seen from Table 4 that even with intensive subsurface feeding of water from below, the optimum moisture for grasses and vegetables could have been reached with depth to ground water less than 90-120, and less than 150-190 cm, respectively. Actually, as will be seen later, the value of subfeeding is not great. During individual periods the moisture in the 0-80 cm layer is diminished under the influence of evaporation which exceeds the subsurface feeding and the precipitation. It is reduced to 70% when the depth to ground water H = 80 cm; to 60%, when H = 120 cm; to 35%, when H = 180 cm. In Figure 2 the moisture is plotted for the following dates: 1959 — May 5, 16; June 1, 12, 16, 20, 26; July 1, 6, 11, 16, 21; Aug. 1, 6, 16; Sept. 2, 11, 16, 26, 30. These data show that even with shallow drainage the soil moisture in the upper horizon drops to 30% during individual periods. With deeper drainage a lowering of moisture to WM was noted in the layer of 20-50 cm.

The analyses of moisture diagrams showed that during the growing season optimum moisture is assured when the depth to ground water is close to those indicated by Lebedevich (70-100 cm) (16). Thus, the greatest amount of available moisture is determined also by capillary properties of the soil and by the depth of the ground water as well as by the hydrothermic

Table 3

Limiting moisture content of various layers of soil above ground water with $H_k = 2.5$ m

Indices	Depth to ground water, cm					
	50	100	120	150	180	200
Moisture-holding capacity (MC)						
Layer 0– 50	437,0	429,8	426,8	422,5	426,0	416,2
" 0– 80	—	690,7	685,2	680,5	679,3	669,9
" 0–100	—	866,8	859,5	852,3	851,4	838,7
Moisture retention capacity (fd. moist.cap. (FMC)						
Layer 0– 50	395,4	348,3	327,7	293,7	255,9	227,3
0– 80	—	580,4	548,5	496,8	439,3	396,4
0–100	—	743,7	705,0	642,0	572,7	521,0
Maximum available moisture						
Layer 0– 50	273	228	208	174	137	111
" 0– 80	—	387	356	306	249	209
" 0–100	—	501	465	404	335	286

Note: Comma represents decimal point.

Table 4

Depth to ground water that assures optimum soil moisture in the active layer with FMC (field moisture capacity)

Soil moisture in % of field capacity	$F_k = 2{,}0$ м			$H_k = 2{,}5$ м		
	Layers					
	0–50	0–80	0–100	0–50	0–80	0–100
	Depth to ground water, cm					
80	87	100	110	108	120	130
60	152	168	178	184	192	208

conditions and by WM. Moisture in excess of the field moisture capacity was observed only in the winter period when the frozen layer was supersaturated by migrating water.

With deep lying ground water the development of plants and therefore their yields depends primarily on precipitation. During dry years and in regions with low summer precipitation plants will invariably suffer from moisture deficiency, i. e. from drought. Plants experience the greatest moisture deficiency when the dry periods come at the beginning of the growing season when the root system is poorly developed. During the second half of summer drought is less harmful because by this time the plants have rooted and the root system supplies the plant with moisture from lower lying layers (17). On well-drained peat the active layer of soil is considerably greater than in the case of shallow drainage. With a depth to ground water at 145 and 170 cm, Ignat'yeva (14) observed the penetration of the root system of cabbage to a depth of 90 cm. With a depth to ground water of 80 cm the root system penetrated to 50 cm and so on. Plants with shallow roots can suffer from drought more at the beginning of reclamation of bogs because later on the moisture properties and the moisture regime of the peat change in a direction more favorable to plants.

In planning the moisture regime of drained land it is necessary to pay particular attention (aside from the total water supply of the region) to the distribution of precipitation within the year.

Without dwelling on many unquestionable advantages of deep drainage as well as on the work which showed positive effects of the lowering of the ground water on yields, we shall point out that a number of investigations carried out in the region of excessive wetting of the forest zone showed reduction in crop yields with the higher intensity of drainage. Ivitskiy (13), as a result of 3 years of experiment in Belorussian SSR arrived at the following conclusion: "With large fluctuations of ground-water levels and poor cultural practices on peat soils, deep lowering of ground water is intolerable." Observations of the growth and development of plants in our experimental areas showed that during individual periods, the plants suffered from moisture deficiency. The observations of yields on experimental areas carried out by the

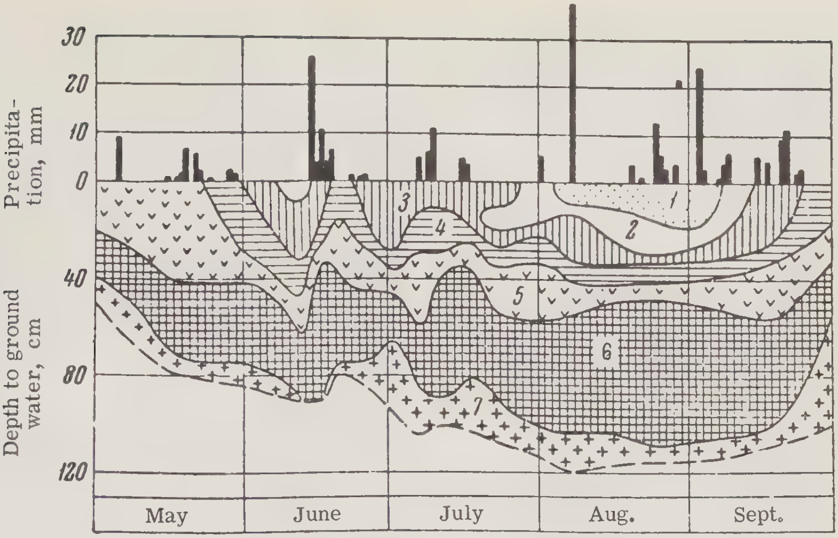

Fig. 2. - Dynamics of soil moisture during the summer period at point 1. Amounts of moisture in % of volume.
1 - 20%-30%; 2 - 30%-40%; 3 - 40%-50%; 4 - 50%-60%; 5 - 60%-70%; 6 - 70%-80%; 7 - 80%-90%; dashed line - ground-water level.

staff of the Meshchersk ZOMS in 1959 showed that "The highest yields of potatoes were obtained with a ground-water level of 99 cm. Lowering it to 160-170 cm greatly reduced the yields" (8). The cited reduction in yield is in our opinion due not only to the low level of ground water but also to the low state of cultivation of the peat soils and to lower amounts of precipitation at the beginning of the growing season.

During dry periods greatest loss of moisture through evaporation is observed in the upper horizons. At lower depths the soil moisture remains unchanged (Figs. 1, 2). Analyses showed that this depth is determined by the ground-water level. It could be assumed that the layer 60-80 cm above the ground-water level when the ground water is deep is practically free of the influence of evaporation (under conditions of this particular region). The moisture deficit which does arise is quickly compensated by intensive capillary sub-feeding.

When evaporation is involved, the relationship of soil moisture to the ground-water level can be determined only after all the elements determining the water balance of the soil layer are taken into account. Apropos we shall point out that computations with Budagovskiy's formula (6) give good results on drained peat lands when there is no ground water feeding. During rainfall the water entering the soil as a rule wets the upper horizons to FMC and gradually penetrates downward. Redistribution of moisture in the zone of aeration and changes in ground-water levels connected with it continue over a considerable period after precipitation ceases (a rise of ground-water level is sometimes observed 1 or 2 days after precipitation).

Ground water levels were recorded with a Valdri water-level recorder which was set up on an observation well with a depth of 120-160 cm. The instrument showed that under these conditions the rise (as well as the fall) of the level is smooth. In the spring of the year when the soil is being saturated by capillary action, a rise in ground water is observed irrespective of its depth, practically with every rain. In the summer period some rains show no effect at all on the ground-water level. Thus, in 1959, during the period of June — September percolation was observed to a depth greater than 50 cm only during three 5-day periods where the depth to ground water was about 1 m and not even once where the depth was about 1.6 m. During periods of heavy precipitation flooding of the root systems of plants with all its undesirable consequences is possible when the drainage system is shallow. With deeper drainage this does not occur.

No summer surface run-off is observed in drained bogs. It should be pointed out that with the rise of ground-water levels not all the empty pores are filled with water. Part of them remains occupied by air (entrapped air). At the water table, the entrapped air occupies on the average 5.6% of the volume of the soil. When the ground water rises the proportion of the volume occupied by entrapped air is reduced. When the level rises 40 cm it constitutes 2.7% and when it rises 100 cm, it is 1.6%, etc.

Evaporation from the Soil Surface

In the tables of the water balance below are shown values of evaporation for individual periods. Therefore, we shall now limit ourselves only to several remarks.

Evaporation from a bare surface is determined by the combined action on soil water of meteorological factors: air temperature, air humidity, wind velocity, and solar radiation. Soil conditions, especially the moisture content of the soil which to a great degree is determined by the depth to ground water, have a marked effect on evaporation.

Comparing the experimental material with 8 most commonly used formulas by meliorators for the determination of evaporation showed that the best results are obtained by the formula of Ivitskiy (13) with coefficients $a = 0.94$ and $n = 1.3$, and with the formula of Aver'yanov (1) with $n = 1$. The first formula takes into account directly only the depth to ground water. The second formula uses, in addition, the height of capillary rise.

Maximum evaporation from a bare surface during individual days at the beginning of summer reaches 5 mm; the average evaporation at station 1 (shallow drainage) in May-June exceeded 2.5 mm per day, in July it ranged from 1.6-2.7 mm, in September it was about 1 mm per day. On the area with deep drainage ($h = 1.5$-1.7 m), the intensity of evaporation in summer exceeded 2 mm only during rainy periods. During dry periods it was less than 1 mm per day Aug. 11-20, 1959 — 0.76 mm per day).

During moist periods in the fall and especially in late spring the evaporation exceeded the evaporativity on the average by 19%. This is explained by the increase in the evaporating surface owing to irregularities of the soil in comparison with a smooth water surface (we computed evaporativity by the widely known formula of Ivanov (11) in which evaporativity is a function of temperature and of humidity of the air). The possibility of using this formula in such cases is pointed out in particular by Alpat'yev (3).

Total evaporation (evaporation from the surface of the soil plus transpiration) greatly exceeds the value of evaporation from a bare soil, and for some periods also the evaporativity. Thus, total evaporation of potatoes for two 10-day periods — from July 21-Aug. 10, 1959 was 15% greater than evaporativity (Table 5).

The ratio of total evaporation to evaporativity is quite close to that obtained under other natural conditions and for other soils (3).

Determination of the Value of Ground Water Sub-Feeding and the Water Balance of the Soil Layer

The quantitative characteristic of the water regime is the water balance. However, to set up the water balance we still lack the elements which take into account the moisture circulation between the zone of aeration and the ground water — the value of ground-water feeding during dry periods and the amount of infiltration during rainy periods. It should be pointed out that as yet there are no sufficiently workable methods for determination of these quantities. The methods which are sometimes used to determine sub-feeding by means of evaporimeters with screen bottoms have a number of serious defects (7).

We calculated this quantity from the water balance of the soil layer, to increase the accuracy we determined the dynamics of the moisture supply in the 0-50 cm layer with isotopes. At a depth of 50 cm, at points where evaporation was observed in the fall, radioactive isotopes Co 60 were placed (in a collimator-container), the intensity of radiation of which was registered by means of a counter and radiometer IVP-64. The counter was placed on the surface of the ground always in precisely the same position. The computation of the changes in soil moisture were carried out in accordance with accepted methodology (5).

In Table 6 the moisture balance in the layer 0-50 cm under a bare surface is given for several periods in 1958 (moisture was determined by means of isotopes).

As seen from Table 6 the entry of moisture into the upper layer from the ground water was not great during the wet year of 1958. The moisture deficit in the soil was in the main compensated by frequently occurring rains. A different picture was observed in the drier year of 1959, especially under agricultural crops (Table 7).

For individual short periods the balance may be only approximate owing to unavoidable errors of measurement. However, mean values and total values derived from them express the actual situation with sufficient accuracy.

The data in Table 7 show clearly that with deep drainage the plants have fully utilized the precipitation that fell during the growing season.

Table 5

Comparison of evaporation from the soil and of total evaporation with evaporativity

Observation Point	Crop	Growing season	Evaporation from bare surf (soil) E, mm	Evaporativity E_0, mm	Total evaporation E_s, mm	$\frac{E_t}{T_o}$
1	Sunflowers	June 11-Sept.30	204,6	346,2	321,3	0,93
2	Potatoes	June 11-Sept.30	162,9	346,2	310,5	0,90

Note: Comma represents decimal point.

Table 6

Moisture balance in the 0-50 cm layer

Periods	Average depth to ground water, cm	Precipitation	Evaporation	Change in moisture content, mm	Moisture exchange with lower layers, mm	
		мм			Inflow	Outflow
June 2-8	56	9,1	20,2	— 3,7	7,4	—
June 9-17	49	31,4	25,3	— 0,1	—	6,2
June 18-July 10	69	16,5	70,4	—39,0	14,9	—
July 11-20	92	0,2	31,1	—23,1	7,8	—
July 21-31	101	13,2	26,3	—10,1	3,0	—
Aug. 1-5	104	28,5	15,6	+10,0	—	2,9
Aug. 6-14	85	31,7	17,4	+ 3,7	—	10,6
Aug. 15-18	75	2,5	5,4	— 3,4	—	0,5
Aug. 19-22	76	13,4	9,6	+ 1,4	—	2,4
Total for 82 days	—	146,5	221,3	—64,3	33,1	22,6

Note: Comma represents decimal point.

Table 7

Moisture balance in the 0-80 cm layer under different crops, mm

Periods	Mean depth to ground water, cm	Effective precipitation	Evaporation	Moisture content in layer			Moisture exchange with lower layers	
				Initial W_H	Final W_k	Difference $W_k - W_H$	Inflow	Outflow
Sunflowers								
May 5-15	66	9,5	41,9	619	564	— 55	—	22,6
May 16-31	78	19,2	40,2	564	538	— 26	—	5,0
June 1-15	88	0	42,4	538	511	— 27	15,4	—
June 16-19	84	52,1	5,3	511	546	+ 35	—	11,8
June 20-25	81	0	16,6	546	523	— 23	—	6,4
June 26-30	90	0	12,8	523	512	— 11	1,8	—
July 1-5	96	0	18,0	512	503	— 9	9,0	—
July 6-10	97	27,3	8,9	503	524	+ 21	2,6	—
July 11-15	96	0	16,5	524	516	— 8	8,5	—
July 16-31	102	15,1	81,4	516	466	— 50	16,3	—
Aug. 1-15	109	37,3	61,9	466	461	— 5	19,6	—
Aug. 16-31	110	28,7	39,8	461	452	— 9	2,1	—
Sept. 1-16	108	39,1	20,0	452	473	+ 21	1,9	—
Sept. 17-Oct. 15	99	53,1	28,7	473	501	+ 28	3,9	—
Total for 164 days	—	281,4	434,4	—	—	—118	80,8	45,8
Potatoes								
May 5-15	125	9,5	34,7	497	482	— 15	10,2	—
May 16-31	142	10,2	33,8	482	482	0	14,6	—
June 1-15	155	0	24,7	482	469	— 13	11,7	—
June 16-30	158	52,1	25,9	469	493	+ 24	—	2,2
July 1-15	156	27,3	43,4	493	485	— 8	8,1	—
July 16-31	162	15,1	91,1	485	444	— 41	35,0	—
Aug. 1-Sept. 1	167	66,0	108,6	444	451	+ 7	49,6	—
Sept. 2-16	169	39,1	24,2	451	450	— 1	—	15,9
Sept. 17-Oct. 15	164	53,1	18,9	450	465	+ 15	—	19,2
Total for 164 days	—	281,4	405,3	—	—	— 32	129,2	37,3

Note: Comma represents decimal point.

The flow of water into the 0-80 cm layer was to a large degree determined by the depth of penetration of roots which extracted water from lower-lying horizons. This is confirmed especially during the dry periods at the beginning of June when the atmosphere had a high evaporation capacity, the inflow of water into this layer was not great, and only subsequently with the development of the root system in depth did it reach maximum values. At the first station the inflow was less (although the crops were about the same or nearly the same as far as water requirements are concerned). This is explained by the complete development of the root system in the 80 cm layer. The moisture content in this layer at both stations not once fell to the wilting.

In addition to the general water balance, we ran the moisture balance for each horizon which made it possible to set up a scheme of moisture movement in the aeration zone during the growing season (Fig. 3). To facilitate the analyses of this scheme we give a brief description of the station from the standpoint of the effect of the drainage network. The surface of the land during the summer was 130 cm above the line joining the water level in neighboring canals (the amplitude of fluctuation of water levels in the canals in the summer was about 5-10 cm; therefore, the indicated value can be considered approximately constant). This value could have been the limiting one of lowering of the ground-water level if there was no continued inflow of ground water into the bogs from beyond its boundaries. During the winter when ground water is almost wholly under the influence of the drainage net, it stands 36 cm above this base line. This value is determined by the extent of sub-feeding of the bog at the expense of allochthonous water. With slight approximation this applies also to the summer period. Then for this particular point the limiting depth subject to the influence of the drainage net should be considered 131-36 = 95 cm.

It can be seen from Figure 3 that during the first period (May 5-15) the moisture in the upper 60 cm was reduced under the influence of evaporation. At the same time the ground-water level dropped under the influence of the drainage net. This drop led to moisture loss at a depth of 60 cm as a result of reduction in the water retention capacity at this level. Altogether, 12.6 mm entered the ground water from 2 horizons (60 and 70 cm).

During the second period, the influence of evaporation was limited only to the two upper horizons. As a result of continued dropping of the ground-water level, under the influence of the drainage network, there was a redistribution of moisture in the lower horizons.

During the period June 1-16, as a result of increased evaporation, the moisture was evaporated from the entire soil profile. The precipitation in the following period replenished the moisture in the horizons and caused a rise in the ground water.

In two subsequent periods, the evaporation gradually affected all the deeper horizons and under the influence of the canals there took place a lowering of the ground-water level until it reached the limiting value. The lowering continued further but under the influence of evaporation there was a continued upward movement of water from the ground water. The precipitation was fully absorbed by the upper dried soil layers.

With a decrease in evaporativity and under the influence of the pressure of ground water that was coming from outside, its level began to rise (mid-August) until it reached its limiting value. The precipitation and ground water sub-feeding gradually eliminated the moisture deficit in the zone of aeration. After that, the water regime of the aeration zone was determined entirely by the relation between ground water inflow and outflow.

The setting up of the balance for drained areas showed that the volume of outflow in the canals during the summer period was almost equal to the inflowing allochthonous water. With increase in depth of the canals the inflow of ground water increases and therefore the volume of outflow increases. Because the stabilization of the levels on the elements of the landscape adjoining the bog under the influence of the canals, proceeds over a considerable period of time, the inflow of ground water into the bog and the extent of sub-feeding of the aeration zone by higher pressure are greater during the first years of reclamation of the bog than during subsequent years.

Conclusions

1. The water regime of drained bogs, during the summer period, is determined by the depth to which the ground water is lowered. The elements of the water balance — soil moisture, evaporation, transpiration, infiltration, ground water sub-feeding, and run-off are different on areas with different depths to ground water.

2. Moisture content of the soil profile on drained bogs when there is capillary saturation has a parabolic character which is well-expressed by S. F. Aver'yanov's equation.

3. During the dry, summer periods, there is a reduction in moisture content of the upper horizons which practically does not encompass the 60-80 cm above ground water where the reduction in moisture is compensated by intensive capillary sub-feeding.

4. On areas with great depth to ground water the development of plants at the beginning of the growing season (when the root system is not fully developed) is determined to a considerable extent by the amount and the time of distribution of precipitation. In dry years, lowering of yields is unavoidable unless artificial means are used to replenish the moisture deficit.

5. Excessive lowering of ground-water levels in bogs (to a depth greater than 1.2-1.4 m) is not advisable under conditions of the Meshchersk lowlands.

Received September 19, 1960

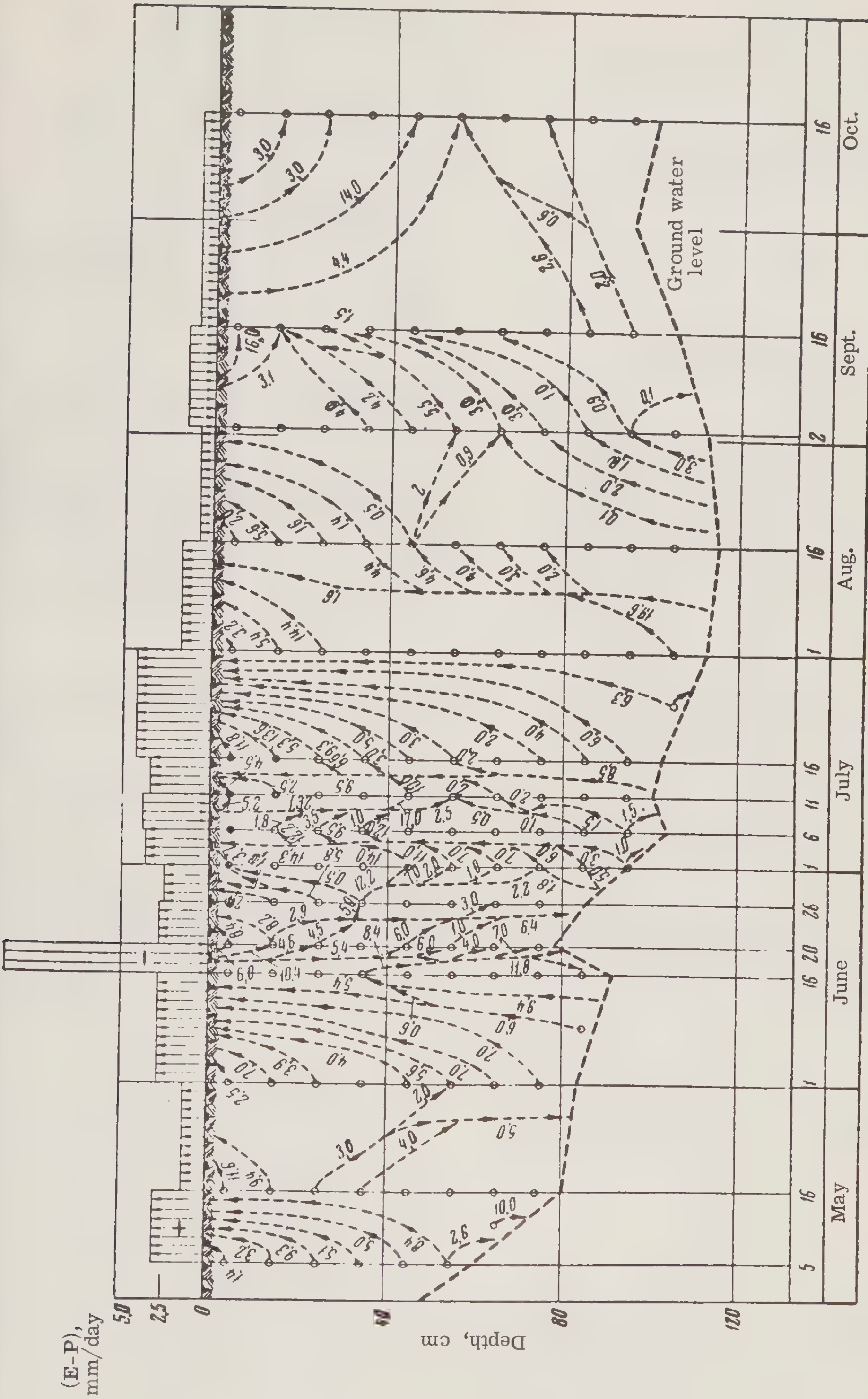

Fig. 3. - Scheme of migration of moisture in the soil (points (circles) indicate horizons; figures near arrows indicate moisture in mm)

BIBLIOGRAPHY

1. AVER'YANOV, S. F. 1959. Problems of improving the regime of ground water. Referat. Fondy bibl. im. V. I. Lenina.

2. AVER'YANOV, S. F. 1949. An approximate evaluation of the role of filtration in the zone of the "capillary fringe." Dokl. Akad. Nauk SSSR, Vol. 69, No. 3.

3. ALPAT'YEV, A. M. 1954. Moisture circulation of cultivated crops. Gidrometeoizdat, Leningrad.

4. AMNUIL, KH. I. 1956. Methodology of determination of the lower limits of available moisture for plants in peat soils. Tr. Bel. n.-i. in-ta melior. i vodn. khoz., Vol. 7, Minsk.

5. ASTAPOV, S. V. 1958. Meliorative soil science (practicum). Izd. 2. Sel'khozgiz.

6. BUDAGOVSKIY, A. I. 1956. Fundamental laws of evaporation in the steppe zone. Izv. Akad. Nauk SSSR, Ser. geograf. No. 3.

7. VASIL'YEV, IS. 1950. Water regime of podzolic soil. Tr. Pochv. in-ta. Vol. 32.

8. GOLOVKO, D. G. and KH. N. STARIKOV. Effect of drainage standards upon the yield of potatoes and of other crops in peat soils (according to observations in practice). Manuscript. Scientific report of the Meshchersk ZOMS for 1959. Vol. 2. Arkhiv Meshcherskoy ZOMS.

9. ZAYDEL'MAN, F. R. and V. G. VINOGRADOY. 1960. Lower boundary of available moisture for plants in peat soils. Pochvovedeniye, No. 7.

10. ZVERKOV, I. P. 1953. The Meshchersk lowlands (physico-geographical characteristics): Dissertation, 1953. Fondy bibl. im. V. I. Lenina.

11. IVANOV, N. N. 1948. Landscape-climate zones of the earth. Zap. geogra. ob-va Vol. 1, Novaya ser.

12. IVITSKIY, A. I. 1958. Investigations of drainage standards of bogs. Tr. Bel. n.-i. in-ta melior. i vodn. khoz. Minsk.

13. IVITSKIY, A. I. 1958. Basic attainments of the meliorative science in planning and design of drainage systems under conditions of the Belorussian SSR. Minsk.

14. IGNAT'YEVA, V. M. 1955. Reclamation of bogs and the improvement of sandy soils of the Meshcherak lowlands. Sel'khozgiz.

15. KOSTYAKOV, A. N. 1941. Academician V. R. Vil'yams and the science of melioration. Izd. Mosk. Gidromeliorat. in-ta.

16. LEBEDOVICH, N. F. 1954. Water regime of peat-bog soils and yields of crops, Tr. In-ta melior., vodn. i bolotnogo khoz., Vol. 5, Izd. Akad. Nauk BSSR, Minsk.

17. RUSSELL, E. 1955. Soil conditions and plant growth. Izd. il., Moscow.

18. RODE, A. A. 1956. Water regime of soils and its types. Pochvovedeniye, No. 4.

19. SEREDA, N. I. 1954. Critical moisture of peat soils. Tr. Ukr. NIIGiM, vyp. 76, 2, Kiev.

20. SKRYNNIKOVA, I. N. 1959. The effect of regulation of the water regime of cultivated peat bog soils on the direction of soil processes in them. Pochvovedeniye, No. 1.

METHODS

MELIORATIVE EVALUATION OF IRRIGATION WATER WITH ALKALINE REACTION

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In our previous paper (5) we discussed the methodology of the meliorative evaluation of irrigation water with a neutral reaction. We set out definite physical-chemical patterns relating to those conditions, which under the influence of irrigation with mineralized water, solonetz processes can be developed. In connection with that, we introduced the concept of "critical" (equivalent) ratio of the concentration of alkali-earth cations to the concentrations of salts of sodium in the water

$$X = C_{Ca(+Mg)} : C_{Na}$$

At this "critical" ratio the irrigated soil adsorbs sodium ions in amounts of about 10_2 of its cation exchange capacity, a level of adsorption which determines the lower limit of soil salinization (1C).

It was further found that the value of the cited "critical" ratio X is not constant, but is a function of the degree of mineralization of the irrigation water and is expressed by the empirical equation: $X = kC$, where k is a constant (equal to 0.23) and C is the salt content in g/liter of the irrigation water. This made possible a simple practical determination of the melioration value of water from data on the total concentration of salts and their equivalent ratio

$$C_{Ca(+Mg)} : C_{Na}$$

A more precise physical-chemical method of determining X with data on the constants of the adsorption exchange of bivalent ions with sodium ions requires preliminary investigation (4). It is true that this method is widely used in the science of melioration (18, 19, 20, 21, 22) and that in such use the values of the exchange constants are computed principally by the adsorption exchange equation of Gapon (19). In soils more precise determination of the constant of adsorption exchange of bivalent with monovalent cations can be made only by using the following equation (law of mass action);

$$\frac{\sqrt{X_{Ca(+Mg)}}}{X_{Na}} = K \frac{\sqrt{C_{Ca(+Mg)}}}{C_{Na}},$$

In experiments, it is necessary to insure the constancy of the ionic strength of the solutions (13, 14, 9, 2). A number of investigators in the field of soil melioration carry out the evaluation of irrigation water purely experimentally in a rather cumbersome way (6, 12, 8).

While our proposed method for meliorative evaluation of irrigation water with a neutral reaction can be considered worked out, this can not be said with regard to water with alkaline reaction. It was therefore natural to continue our investigation of this more complicated problem.

The complexity of the problem lies in that in an alkaline environment there takes place, in addition to the equivalent exchange of adsorbed bases of the soil with cations of the solution, also a change in the cation exchange capacity of the soil in accordance with equation $E = K_1 + K_2pH$. In this equation E is the capacity exchange of the soil, K_1 and K_2 are constants. This relationship was studied in detail by Soviet investigators (13, 1, 11). The exchange capacity changes also with the concentration of the competing cations in the solution. In addition, the anion part of the salt exerts a great influence on the adsorption of the cation in the salt. For instance, in the presence of bicarbonate and carbonate of sodium there takes place an increased adsorption of sodium ions by the soil. This is due to the chemical precipitation of the exchange calcium which is liberated from the soil in the form of calcium carbonate.

The elucidation of the quantitative laws of most of the cited reactions was the object of our further experimental investigations. The end aim was to determine the dependence of "critical ratio" in irrigation water

$$\frac{C_{Ca+Mg}}{C_{Na}} = X_{10}$$

on these parameters.

Experimental Part

Change in the adsorption capacity of soil with the pH of the solution. In one of the previous papers of Antipov-Karatayev, Vishnyakov, and Sochevanov (1), the following data were given on the value of exchange capacity of samples of chernozem and red earths obtained by treating them with buffer solutions in a mixture with salts of calcium and with definite equilibrium values of pH (Table 1).

Table 1

Change in the value of exchange capacity for calcium, in meq per 100 g, with the pH of the solution

Soil	pH of the medium					
	5,0	5,2	6,62	7,0	8,50	10,0
Chernozem	20,1	—	25,8	—	29,1	40,9
Red earth	—	11,8	—	13,0	28,2	Not det'd

Note: Comma represents decimal point

As can be seen from these data, there is in the range of pH from 5-10, a two-fold increase of the exchange capacity of chernozem (for calcium). Similar results were obtained by Materova (11) in experiments on the adsorption of barium ions by glauconite in the range of pH from 4.5-11.0 (from 17-34 meq per 100 g of the absorbent). A straight line relationship of the exchange capacity with pH was established.

In the new experiments, we investigated this problem by using various buffers in solutions of a mixture of calcium and sodium chloride. Ordinary chernozem was used, samples of it were washed with indicated buffer solutions to a point where the filtrate reached the original pH. After this the excess buffer solution was washed out of the soil with a weak solution of alcohol. The adsorbed calcium and sodium were removed by a 0.02 n HCl. The calcium and sodium in the filtrate were determined (by the trilonometric method and with a flame photometer, respectively). The results are shown in Table 2.

The values given in Table 2 support the previously determined relationship of the value of exchange capacity of the soil on the pH of the solutions with which the soil is treated. The constant k_2 value (slope coefficient) is notably greater with a borate buffer than with a sodium diethylbarbiturate buffer. Thus, we can judge indirectly the anion effect of the solution on the adsorption of the cation (calcium) by the soil. A more detailed analysis of the problem will require additional investigations.

Changes of the adsorption capacity of the soil with the concentration of salt solution. The data in Table 3 show clearly the effect of the pH of the medium on the value of the adsorption capacity of the soil. The effect of the concentration of the solution on the value of the exchange capacity is noticed when comparing solutions $C_1 = 0.05$ n; and $C_2 = 0.15$ m. This effect does not appear with higher concentrations of solution of calcium chloride.

Relationship of the "critical ratio" $X_{10} = \frac{(Ca^{++})}{(Na^{+})}$ on the pH and the concentration of the solution. We shall consider the basic question on the effect of the total concentration of the calcium chloride solution with various pH values on the shifting of the "critical ratio:" $X_{10} = C_{Ca(Mg)} : C_{Na}$, which ratio determines the lower limit of solonetzization of the soil (10% of exchangeable sodium of the adsorption of the soil). Table 4 gives corresponding values obtained experimentally for the same chernozem soil.

The values in Table 4 confirm the conclusion from the experiments with neutral solutions (5) regarding the relationship of the value of the critical ratio, $X_{10} = Ca^{++}/(Na^{+})_{10}$ on the degree of mineralization of the water (solution) and on the value of the equivalent ratio of the calcium ions and sodium ions. With a mineralization of 1 g of salt per liter of irrigation of water the critical ratio shifts towards higher values of sodium (more than 80%). With a mineralization of 3 g salt/liter the critical ratio stabilizes at about 70% of sodium ion in the solution and with 5 g/liter the critical value corresponds to a sodium content of about 60%. In other words, the relationship is expressed by the same straight line equation ($X = KC$) which was derived from the experiments with neutral solutions of a mixture of $CaCl_2 + NaCl$. This of course facilitates the meliorative evaluation of irrigation water regardless of the change of the reaction of the solution, provided the solution does not contain

Table 2

Change in the value of adsorption capacity of Chernozem (for Ca) in meq/100 g with the pH of the solution (using various buffers)

Buffers with total mineralization of solution 3 g/liter,	pH of solution		
	8,0	9,0	10,0
Sodium diethylbarbiturate	63,51	64,67	67,97
Borate	59,65	64,21	74,13

Note: Comma represents decimal point

Table 3

Effect of total concentration of calcium salts in the solution on the value of adsorption capacity of Ca ions of a chernozem soil in meq/ 100 g of adsorbent sodium diethylbarbiturate buffer

Concentration of $CaCl_2$ solution meq/liter	pH of solution.			
	7,0	8,0	9,0	10,0
50	52,96	59,10	60,13	—
150	—	63,52	64,21	66,39
250	—	62,03	63,19	64,56

Note: Comma represents decimal point

such ions which could lead to chemical precipitation of the competing bivalent cations (Ca + Mg) (see the following part of this paper).

Critical ratio for solutions of a mixture of MgCl and NaCl with varying pH values. The presence in most irrigation waters of Mg in addition to salts of Ca and Na made it necessary to conduct special experiments with the same chernozem using mixtures of solutions of MgCl and NaCl. The results are shown in Table 5. From the values in Table 5, it is seen that the critical ratio ($X_{10} = (Mg^{++}) : (Na^{+})_{10}$) is reached when the proportion of sodium ion in the mixed solution of the chlorides of Mg and of Na is about 60% in the pH range of 8-10. This value (60%) is sufficiently close to the corresponding value for a system of calcium chloride and NaCl (70%, see Table 4). This proves the validity of our proposal to use the general equation

$$X = \frac{[Ca^{++} + Mg^{++}]}{[Na^{+}]_{10}} = kC,$$

in the meliorative evaluation of specific irrigation water. In this equation k = 0.23 which was discussed in our previous paper (5).

Meliorative evaluation of water containing bicarbonates and carbonates of sodium. In the monograph Melioration of solonetz soils of the USSR (3, p. 35) the senior author gave values on the relationship of the adsorbed sodium on the concentration of sodium carbonate solution. This relationship was satisfactorily expressed by the isotherm equation; $y = K_1 + K_2 \log C$ (of sodium carbonate). As was pointed

Table 4

Adsorbed sodium in % of exchange capacity of chernozem soil with various Ca^{++}/Na^{+} ratios in solutions of various concentration and pH values

Concentration of salts g/ liter	Amount of adsorbed Na in % for the following Ca^{++}/Na^{+} ratios in the solutions							
	9 : 1	8 : 2	7 : 3	6 : 4	1 : 1	4 : 6	3 : 7	2 : 8
With pH = 7,0								
1	not det'd	Trace	not det'd	Trace	0,66	1,1	3,3	6,3
With pH = 0,8								
1	not det'd	Trace	not det'd	Trace	0,50	1,5	3,0	5,4
3	0,76	1,3	2,4	2,9	4,0	6,1	8,9	19,9
5				4,3	5,7	7,8		
With pH = 9,0								
1	not det'd	Trace	not det'd	0,56	0,71	1,5	3,1	6,1
3	0,73	1,4	2,4	2,9	4,4	6,3	9,1	13,2
5				4,3	4,9	7,0		
With pH = 10,0								
3	0,97	2,0	2,7	2,8	3,9	5,9	8,7	13,5
5		not det'd		3,8	5,7	7,3	not det'd	

Note: Comma represents decimal point

Table 5

Adsorbed sodium in % of exchange capacity of chernozem soil with various Mg^{++}/Na^{+} ratios in solutions with various pH values and with a concentration of 3 g/liter.

pH of Solutions	Mg^{++}/Na^{+} ratio of solutions			
	6 : 4	1 : 1	4 : 6	3 : 7
8,0	5,1	6,7	9,9	13,3
9,0	5,1	7,1	9,3	13,7
10,0	4,3	6,0	8,0	11,5

Note: Comma represents decimal point

out previously, in this case complex reaction between the soil and the solution takes place, namely, the exchange adsorption of Na by the soil mass intensified by the chemical precipitation of the adsorbed calcium and Mg which are displaced from the soil. In addition, under the influence of the alkaline medium the adsorption capacity of the soil is increased because of participation in the reaction of a number of ionogenic groups of various types (similar to poly-functional organic and mineral ionites [15]). This in turn leads to considerable additional adsorption of sodium. It is for this reason that with sodium carbonate solutions solonetzization of the soil appears quickly even when the irrigation water is only weakly mineralized. We repeated experiments on the interaction of sodium solutions with chernozem soil. We treated identical samples (10 g) with sodium carbonate solution of various concentrations (from 1-10 meq/liter) and passed through the soil sample volumes of the solutions in which the sodium carbonate content was 10 meq (equal to 100 meq/100 g soil). The results are shown on Table 6.

The data in Table 6 show that with a lengthy treatment of the soil with a 0.001 N solution of sodium carbonate it is possible to convert it into a solonetz. The coefficient of adsorption of sodium reaches 23% of the total amount of sodium carbonate (100%). This coefficient increases rapidly with increase in the concentrations of sodium carbonate in the solution and reaches almost 100% when the soil is treated with 0.01 N solution of sodium carbonate. The curve of the relation of adsorbed sodium to the logarithm of the concentration of sodium carbonate shows (Fig. 1) that the adsorption process is satisfactorily expressed by the equation: $y = K_1 + K_2 \log C$ (of sodium carbonate). According to the graphs, $K_1 = 12$ and $K_2 = 0.92$.

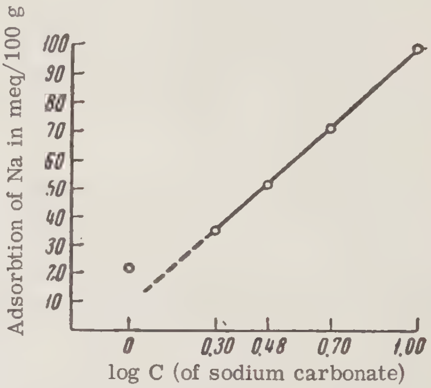

Fig. 1 - Relationship of quantity of adsorbed sodium to the log concentration of sodium carbonate.

Conclusions

The present investigation showed that the adsorption capacity of soils increases linearly with increase in pH of the medium (solution). The amount of exchange-adsorbed sodium in the soil from mixed solutions of salts of calcium (magnesium) and sodium is also increased. Owing to the symbiotic nature of both processes there is no appreciable shifting of the critical ratios

$$X_1 = \frac{[Ca^{++}]}{[Na^{+}]_{10}} \quad \text{и} \quad X_2 = \frac{[Mg^{++}]}{[Na^{+}]_{10}}$$

in comparison with the data obtained in experiments with solutions with neutral reaction. This shows the validity of the relationship found in the experiments with neutral solutions which expresses the relationship of the critical ratio

$$X_{10} = \frac{[Ca^{++} + Mg^{++}]}{[Na^{+}]_{10}}$$

Table 6

Adsorption of sodium (in meq per 100 g of soil) from solutions of sodium carbonate of various concentrations

Concentration of sodium carbonate meq/liter	1	2	3	5	10
Amount of sodium adsorbed as a result of treatment with a total quantity of sodium 100 meq per 100 g of soil	22,82	34,80	50,00	69,56	96,73

Note: Comma represents decimal point

on the general mineralization of irrigation water in the form of the equation $X_{10} = kC$, where k is a constant = 0.23 and C is the total concentration of salt in the irrigation water. This makes possible the meliorative evaluation of irrigation water with the equation cited previously. Water with X_{10} less than that found for the analyzed water would require improvement (either by mixing with fresh water or by introducing Ca salts).

The method of evaluating irrigation water containing bicarbonates and carbonates of sodium is somewhat more complicated, because they can completely precipitate the exchangeable ions of Ca and Mg displaced from the soil and can consequently lead to solonetzization of the irrigated soil. An approximate estimate of the "critical" amount of exchangeable sodium $X_{Na_{10}}$ can be made by considering the content of sodium carbonate in the water keeping in mind that approximately 50% of its Na will be adsorbed by the soil in the first years of irrigation with such water. Improvement of the properties of such water must be made by applying Ca salts (principally gypsum). Meliorators of the Ukrainian SSR prefer to add gypsum beforehand into the upper layers of the soil (12).

When it is necessary to set-up new possible relationships for qualitative meliorative evaluation of irrigation water, we recommend that the outline of the method given at the end of our paper (2) be used.

Received July 7, 1960

BIBLIOGRAPHY

1. ANTIPOV-KARATAYEV, I. N., A. I. VISHNYAKOV, and V. G. SOCHEVANOV. 1933. A study of the nature of the soil adsorption complex. Tieing-up of anions and of calcium in soils and in its components for various values of the pH of the medium. Tr. Leningr. otd. VIUA, vyp. 23.
2. ANTIPOV-KARATAYEV, I. N. and G. M. KADER. 1947. Nature of adsorption of ions by clays and soils. Kolloidn. zh., vol. 9, vyp. 2.
3. ANTIPOV-KARATAYEV, I. N., et al. 1953. Melioration of solonetz soils of the USSR. Izd. Akad. Nauk SSSR.
4. ANTIPOV-KARATAYEV, I. N. and G. M. KADER. 1959. Investigations of exchange reactions in soils utilizing the isotope of calcium. Kolloidnyy zh., Vol. XXI, vyp. 2.
5. ANTIPOV-KARATAYEV, I. N. and G. M. KADER. 1959. Methodology of meliorative evaluation of irrigation water. Pochvovedeniye, No. 2.
6. BUDANOV, M. V. 1956. The effect of irrigation with mineralized water on the soil. Tr. Ukr. un-ta gidrotekhn. i melioratsii, vyp. 77, 31.
7. IVANOVA, YE. N. 1933. Materials on the study of the adsorption capacity of soils. Tr. Pochv. in-ta Akad. Nauk SSSR, Vol. VIII, vyp. 8.
8. KRUPKIN, P. I. 1960. Peculiarities of the steppe and forest-steppe alkali soils of the Omsk Oblast' and certain questions on the genesis of alkali soils. Avtoref. dis. na soisk. st. kand. biol. nauk, Omskiy s.-kh. in-t.
9. LOBANOVA, T. A. 1955. The significance of exchangeable calcium and sodium in the melioration of soils. Tr. Pochv in-ta Akad. Nauk SSSR, Vol. 47.
10. MAMAYEVA, L. YA. 1956. Colloidal-chemical method of determining the quantities of meliorative substances for solonetz soils. Tr. Pochv. in-ta Akad. Nauk SSSR, Vol. 51.
11. MATEROVA, YE. A. 1945. Exchange of cations on glauconite. Uch. zap. Leningr. gos. un-ta, ser. khimich., vyp. 7.
12. MOZHEYKO, A. M. and T. K. VOROTNIK. 1958. Application of gypsum to solonetzic chestnut soils of the Ukrainian SSR which are irrigated with mineralized water as a method of combating the solonetzization of these soils. Tr. Ukr. in-ta pochvov., Vol. III, Khar'kov.
13. NIKOL'SKIY, B. N. 1939. Theoretical and experimental investigations of ion exchange in a heterogeneous medium. Doctor's thesis. (Leningr. gos. un-t).
14. NIKOL'SKIY, B. N. and V. I. PARAMONOVA. 1945. The exchange capacity and conditional exchange capacity of soils. Uch. zap. Leningr. gos. un-ta, seriya khimich., vyp. 7.
15. TROSTENSKAYA, YE. B. 1959. Ionic exchange resins (ionites) in "Ion exchange and its application." Izd. Akad. Nauk SSSR, edited by K. V. Chmutov.
16. ANTIPOV-KARATAYEV, I. N. and G. M. KADER. 1958. Untersuchungen der Austauschreaktionen in Böden mit Hilfe des Kalziumisotops (Ca^{45}) Verhandl. II und IV Kommissionen der Intern. Bodenk. Gesellsch. v. II, Hamburg.
17. ARANY SANDOR. 1958. The use of alkaline Waters for Irrigation. Rapp. (Commiss. IV et VI). VI Congress Intern. Sci. du Sol. Paris.
18. BANERJEE. 1959, N 1. Somit. Some Aspects of Salt-Affected Soils of West Bengal. Soil Sci., vol. 88, X.
19. BOWER, C. A. 1959, N 1. Cation exchange Equilibria in Soils affected by Sodium Salts. Soil Sci., v. 88.
20. FINE, L. O., E. J. WILLIAMS, F. WIERSMAN, and C. R. UMBACK. 1959. A study of the Sodium adsorption ratio and residual sodium Carbonate Concepts of Irrigation Waters as they affect exchangeable Sodium of Soil under semiarid Conditions. Soil Sci. Soc. Amer. Proc., v. 23, 4.
21. FRIED MARICA. 1959. Exchangeable Sodium in Calcareous Soils. Soil Sci. Soc. Amer. Proc., v. 23, p. 2.
22. RICHARDS, L. A. (Editor). 1954. Diagnosis and improvement of Saline and Alkali Soils. U. S. Salinity Laboratory Staff, Agriculture Handbook, 60.

MICROELEMENTS IN THE SOILS AND PLANTS OF USTYURT

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In order to complete the information on soils of Ustyurt and to clear-up some phases of their genesis we undertook the study of distribution of microelements in the soils and plants of this region. For this purpose a trip was made through the central part of Ustyurt approximately along the forty-third North Latitude. In the course of this trip we selected areas at 50-100 km apart on which we collected plants and made borings. Concurrently with the description of the soil profile, samples were taken from each genetic horizon. In the laboratory the plants were ashed (tops and roots separately). The content of microelements was determined in the ashes of the plants in all samples of the genetic horizons of the soils and in the dry residue of the water extract of each sample.

The determination of the microelements was done at VIMS (under the direction of A. N. Rusanov) with a quartz spectrograph by the method of semi-quantitative spectroanalyses. The methodology used does not permit certain determination of the amount of elements in each sample. This inconvenience is eliminated to some extent by obtaining mean values of several determinations. The mean values were determined by dividing the sum of the total content in the samples on the number of samples in which the elements were found.

To determine the composition of the samples we carried out a mineralogical study using crystal-optical, chemical, thermal, and X-ray structural analyses.

Soils of the central part of Ustyurt are characterized on the one hand by uniformity as to type, and on the other by pronounced complexity. The predominating soils are the gray-brown. The complexity of the soil is expressed in its varying solonchak in the porous surface crust; it is emphasized by the complexity of the vegetation. Anabasis salsa predominates on the solonchakous gray-brown soils with a thick compact surface crust. Sages develop on the non-saline soils while on the gravelly soils there is Salsola arbuscula. The plain relief and the deep ground water result in a slight development of solonchak soils which are localized within the boundaries of the Barsa-Kel'mes depression. All the soil profiles investigated are outside the region of solonchak soils in the area of the gray-brown soil complex. Parent material everywhere is a fine-earth clay loam deposit of Quaternary age. The profile of various parts of the complex is as follows:

1. Surface crust with characteristic rounded pores, polygonal cracks, and a thickness of 3-4 cm to 6-7 cm.

2. Under the crust is a light-gray friable organic horizon; its thickness is 10-15 cm.

3. A compacted brown horizon with infrequent whitish specks; its thickness is 8-15 cm; sometimes this horizon is very poorly pronounced.

4. An exceptionally friable gypsum horizon filled with small isometric crystals of newly formed gypsum which sometimes form friable spherical concretions; the thickness of this horizon is from 20-50 cm.

Below the profile of gray-brown soils are found:

5. Horizon of columnar gypsum represented by an accumulation of gypsum crystals of thin prismatic or needle-like habitus of vertical orientation. Locally the columnar structure of gypsum is replaced by a columnar spongy structure. The horizon of the columnar gypsum varies in thickness from 1-2 decimeters up to 2 m and more. In some areas it is sometimes lacking.

6. Lime with layers of clay and marl of the sarmat stratum of Miocene.

The results of the spectral analyses of samples of individual genetic horizons of the soil profile as well as the deeper lying formations are shown in Table 1. The results of the spectral and mineralogical analyses lead to the following conclusions:

a) The composition of microelements in the Quaternary deposits and in the soil developed on them is more varied than in the eluvium of the parent rock. The content of microelements in the Quaternary deposits in the soil exceeds by several times the content of such elements in the parent rock. The mineralogical studies show that Quaternary deposits are composed

Table 1

Distribution of several microelements in the profile of Ustyurt soils, $1 \times 10^{-3}\%$ (averages for 10 soil profiles)

Genetic horizons	Ti	Mn	V	Cu	Ni	Co	Zr	Ga	La	Y	Yb	Sn	Be	Sc	Pb	Zn	Cr	Mo	Sr	Ba
	Accuracy of determinations																			
	1	1	1	1	1	1	1	1		5	1	1	1	5	10	10	10	1	100	50
Crust	90	70	13	3,8	1	0,5	7	1,8	5[a]	4,4	0,7	0,5[a]	—	5[a]	8	—	4,2	0,5[a]	66	26
Organic	60	61	14	3,6	1	0,7	5,6	1,6	5[a]	4,3	0,7	0,5[a]	0,4[a]	5[a]	6,4	4[a]	4,1	0,5[a]	71	33
Above gypsum	65	40	17	2,8	0,8	0,6	3,5	0,9	—	4,0[a]	0,5	0,5[a]	0,4[a]	—	5,5	—	4,3[a]	0,5[a]	64[a]	27[a]
Recent gypsum	57	34	8,9	2,1	0,9[a]	0,6	9	1,3	5[a]	4[a]	0,8[a]	0,5[a]	—	5[a]	6,5[a]	—	4,4[a]	0,5[a]	337	23[a]
Columnar horizon of gypsum	16,7	6,6	2,3	1,5	0,7[a]	—	1[a]	0,7[a]	—	1[a]	1[a]	—	—	—	—	—	0,4[a]	—	433	10
Eluvium of tertiary limestones	21	16,7	1,6	2,1	0,5[a]	—	1,8[a]	1[a]	5[a]	—	1[a]	—	—	—	4,2[a]	—	0,4	—	83	30

Note: [a] indicates elements not found in all samples.

Note: Comma represents decimal point

Table 2

Distribution of water-soluble forms of some microelements in the profile of Ustyurt soils, $1 \times 10^{-3}\%$ by weight of the dry residue [a]

Genetic horizons	Ti	Mn	V	Cu	Ni	Co	Zr	Ga	La	Y	Yb	Sn	Be	Sc	Pb	Zn	Cr	Mo	Sr	Ba
	Accuracy of determinations																			
	1	1	1	1	1	1	1	1	5	5	1	1	1	5	10	10	10	1	100	50
Crust	23,3	52	3,8[a]	4,7	1,1[a]	0,7[a]	3,7	1[a]	5[a]	4[a]	1[a]	0,5[a]	—	5	10[a]	5[a]	4[a]	0,7	321	—
Organic	41,0	40	4,5	6,0	2,1[a]	1	7,0	5[a]	5[a]	5[a]	1[a]	0,5[a]	—	5[a]	5[a]	5[a]	4[a]	0,7[a]	630	10[a]
Above gypsum	33,1	10	6,4	4,9	1,4[a]	0,7[a]	3,8[a]	1,8[a]	7[a]	4,5[a]	1[a]	0,5[a]	—	5[a]	5[a]	5[a]	4[a]	1,9[a]	170	—
Recent gypsum	0,6	0,8[a]	1,1[a]	1,8	2[a]	0,5[a]	—	—	—	—	—	0,5[a]	—	—	—	—	5[a]	1,0	530	—
Columnar horizon of gypsum	0,5	1,7	0,5[a]	1,4	0,7[a]	—	—	—	1[a]	—	—	—	—	—	—	—	—	0,5[a]	530	—
Eluvium of tertiary limestones	0,4	0,5[a]	0,5[a]	2,8	—	—	—	—	—	—	—	—	—	—	—	—	—	0,7[a]	75	—

Note: [a] indicates elements not found in all samples.

Note: Comma represents decimal point.

of entirely different minerals than the deposits of the sarmat layer and are not their eluvium.[1]

The differences between the composition of microelements in all the horizons of gray-brown soils and in the horizon of the columnar gypsum indicate their different origin. In the columnar gypsum the content of minor elements is less than in all the genetic horizons of the gray-brown soils. The only exception is strontium, the content of which in the columnar gypsum is considerably greater than in any genetic horizon or in the eluvium of the parent rock. The strontium content is so high that this element occurs not only in dispersed state but locally forms an independent mineral — celestite in the form of crystals 0.5-0.05 mm in size and of needle-like thin prismatic habitus. It should be pointed out that in some places the horizon of the columnar gypsum is lacking. It was probably destroyed by erosion which preceded the accumulation of thin surface deposits which constitute the parent material of recent soils. The data confirm Gerasimov's premise that columnar gypsum constitutes a relic formation. Analogous formations in the valley of the Syr-Dar'ya were studied by Perel'man (2). According to him they are the result of pliocene soil formation and under hydromorphic conditions.

(c) The distribution of minor elements in gray-brown soils shows a regular accumulation of individual elements in specific horizons. In the surface crust, are accumulated titanium, manganese, copper, zirconium, gallium, and lead. In the crust and the humus horizon under the crust — nickel, cobalt, rare earths, zinc, and barium. In the compacted horizon above the gypsum are possible increased concentrations of vanadium. In the gypsum horizon there is clearly an accumulation of strontium. The distribution of lantanium, tin, berryllium, scandium, and chromium is not clear because of its small content in relation to the sensitivity of the determination.

The study of distribution of water-soluble forms of minor elements gives an idea of their dynamics in the process of soil formation. The water-soluble form of minor elements represents their most mobile and readily migrating part. The content of microelements in dry residues of water extracts from various genetic horizons of gray-brown soils is shown in Table 2. Water extracts were made with a 1:2 ratio of soil to water. Samples were taken between May and 10 and 20, 1959. The results permit the following conclusions.

a) The maximum content of the water-soluble part of almost all minor elements is found in the humus horizon under the crust. There are accumulated even the elements found in the deeper horizons (for instance, strontium). Below

Table 3

Ash content of the tops and of the roots of plants of Ustyurt and of neighboring regions, % of air-dry weight of material

Plants		No. of samples	Ustyurt	No. of samples	Mangishlak	No. of samples	Western Transcaspian
Anabasis salsa	a	5	30,1 (24,3—35,0)	—	—	2	33,3 (32,7—34,0)
	b	5	9,2 (4,4—12,3)	—	—	2	9,5 (7,7—11,5)
Artemisia terrae albae	a	6	15,9 (10,7—20,0)	3	12,1 (10,0—16,0)	5	13,6 (10,0—17,0)
	b	6	8,7 (5,6—14,1)	2	7,5 (6,5—8,7)	5	8,1 (6,5—10,0)
Salsola arbuscula	a	2	7,3 (1,2—8,7)	2	7,35 (5,7—9,0)	1	6,7
	b	2	5,7 (4,3—7,0)	2	6,7 (6,1—7,3)	1	5,3

Note: a - ash of the plant tops; b - ash of the roots. In parentheses are shown the range of ash contents found by ashing.

Note: Comma represents decimal point.

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[1] The relatively large volume of data of mineralogical analyses of Quaternary deposits of Ustyurt do not permit showing the material of mineralogical investigations in this paper. To this interesting question we devoted a special paper in a current issue of the transactions of the geography department of the Lenin Moscow State Pedagogical Institute.

the organic horizon there is noted a relative accumulation of only vanadium and molybdenum. The behavior of zinc, tin, chromium, scandium, and rare earths is not clear because of their low content in relation to the sensitivity of the determination.

It should be stressed that absence of several elements, in particular zinc, is due to the low sensitivity of spectral method of determination.

b) Concentration of some minor elements in the dry residue of water extracts exceeds the value of their concentration and the total mass of the sample. This applies to copper, zinc, possibly nickel, and especially to molybdenum and strontium. In a number of cases elements were discovered in the dry residues which were not found in the analyses of the total mass of the soil (for instance, zinc in samples of the horizon lying above the gypsum, molybdenum in samples from the columnar gypsum horizon). The concentration of other elements is sharply reduced in the dry residues of water extracts. This applies particularly to barium, vanadium, and to a lesser extent to titanium, manganese and zirconium.

c) It should be emphasized that the distribution of the concentration of water-soluble forms of minor elements does not correspond to the distribution of content of water-soluble salts. The content of water-soluble compounds fluctuates strongly in different types of gray-brown soil complex of the central part of Ustyurt. However, in no cases is there an increase of the water-soluble material with depth along the profile. The magnitude of the dry residue of water-extracts of the lower part of the profile (in the gypsum horizon) is several times (sometimes 10 times and more) greater than of the upper part of the profile.

The lack of maximum content of water-soluble forms of minor elements to the sum of dissolved salts indicates that the process of formation of the described soils involves vertical displacement of various chemical elements in opposite directions. This displacement can take place as a result of seasonal movement of capillary moisture and under the influence of vegetation.

To determine the effect of vegetation on the distribution of minor elements in the soil, the ashes of the principal plants and their content of minor elements were determined. These determinations were made separately for the tops and for the roots of the plants. Materials on the ash content of the plants of Ustyurt are shown in Table 3. For comparison, data are also given for plants of adjoining regions — the mountainous Mangishlak and the western Trans-Caspian region. It is interesting to note that according to Shuvalov's data (3), the dry residues of water extracts from dry matter of these plants in Ustyurt are of the same order as the values of the ash content specifically for Anabasis salsa 30%, for sage 15%, for Salsola arbuscula 11% (of the dry weight of the plant mass).

As it clearly follows from Table 3, the greatest ash content is that of Anabasis Salsa — the ash content of sage is almost one-half as

Table 4

Content of some microelements in the ash of plant prevalent in Ustyurt, 1 x 10^{-3}%

No. of samples	Object of investigation	Ti	Mn	V	Cu	Ni	Co	Zr	Ga	La	Y	Yb	Sn	Be	Sc	Pb	Zn	Cr	Mo	Sr	Ba
		Accuracy of determination																			
		1	1	1	1	1	1	1	1	5	5	1	1	1	5	10	10	10	1	100	50
	Sage																				
10	Tops	90	85	6,4	5,0	2,1	0,8	9,3	1,0	5^a	4,8	1,6	0,5^a	—	—	6,0^a	—	4	0,8^a	134	30^a
10	Roots	26	121	4,7	7,3	2,1	0,9	3,4^a	1,3	5^a	4,0^a	1,0	0,5	—	—	4,3	4^a	4^a	1,9	275	62
	Anabasis salsa																				
7	Tops	31	52	3,4	3,8	1,0	0,5^a	7^a	1,4	—	4,0^a	1,0^a	0,5^a	—	—	4,0^a	—	4^a	1,0^a	800	17
7	Roots	16	52	2,9	7,0	1,3	0,5^a	0,9^a	0,9^a	—	—	—	0,5^a	—	—	4,0	4^a	4^a	0,5	1000	48
	Salsola arbuscula																				
3	Tops	46	233	4,6	5,0	1,7	0,7^a	3,5^a	1,0	5^a	5^a	1^a	—	—	—	10,0^a	—	4	0,8	1000	30^a
3	Roots	8	217	5,1	15,0	1,7	0,5^a	1,0^a	1,7	—	—	—	0,5^a	—	—	4,7	4^a	4^a	0,8	1000	30

Note: ^{a}indicates elements found in each sample.

Note: Comma represents decimal point.

much. The ash content of Salsola arbuscula is even smaller. It should be pointed out that the higher ash of the tops of plants is explained not only by higher ash content in the composition of plant tissues, but also by the film of very fine dust on the small leaves of the Anabasis salsa, and of sage which cannot be removed even with very careful washing of the plant.

The contents of minor elements in the ash of plants of Ustyurt are shown in Table 4. It follows from these data that there is a tendency for a relative accumulation in the tops of the plants of titanium, manganese, vanadium, zirconium, lead, and of ytterbium. In the root mass, copper, zinc, molybdenum, strontium, and barium are accumulated. For individual plants, the following can be noted:

a) Anabasis salsa in comparison with sage and Salsola arbuscula is distinguished by a lower content of almost all the minor elements, although it has a considerably larger ash content. The only minor element which is clearly concentrated in the ash of Anabasis salsa is strontium.

b) In the ash of sage, there is a relative increase of molybdenum, and also of titanium, nickel, vanadium, lead, and gallium.

c) In the ash of Salsola arbuscula the content of minor elements is close to that of the ash of sage, although somewhat less. An exception is manganese which shows the greatest content.

Conclusions

The total annual accumulation of plant residues in Ustyurt is, according to Shuvalov (3), about 2 centners per hectare. Therefore, with most prevalent plant associations — Anabasis salsa and sages — the soil receives about 8 and 4 metric tons of ash substances per km². Under Anabasis salsa 1 km² receives from the plant tops something of the order of 200 g of vanadium and copper, 50 g of nickel and molybdenum, and 40-50 kgm of strontium, under sage, vanadium, and copper in the order of 150 g, nickel 50 g, molybdenum 25 g, and strontium more than 4 kgm per km². Apparently, it is precisely this that explains the higher content of each microelement in the uppermost horizon of gray-brown soils (Table 1).

The redistribution of minor elements along the profile of the described soils is due to the vertical movement of soil waters. The depth of wetting of the soil in the central part of Ustyurt is, according to the data of the D'uken (Dauss) meteorological station, normally less than a meter. However, in individual years with wet springs the depth of wetting exceeds 120 cm. Therefore, the entire soil profile of the gray-brown soils (and sometimes even a greater layer) is fully subjected in the vertical movement of water. The more mobile forms of minor elements drop down into the lower part of the profile. (Molybdenum, strontium, vanadium). The water-soluble forms of minor elements move only into the horizon lying under the crust to a depth of 10-15 cm.

The close values of the ash content and of dry residue of the water-soluble matter indicate indirectly, that most of the plant residue is subjected to mineralization. Therefore, a considerable part of the minor elements concentrated in the plants during the process of their life cycle is liberated from the organic matter after the plant dies and is transported with the seasonal movement of soil moisture. In a years time, these elements are absorbed and enter into the composition of the vegetation.

The great depth to ground water, the level nature of the relief, and inappreciable wetting of the surface layers of Ustyurt do not suggest an appreciable removal of minor elements from the soil profile. Therefore, the cyclic character of the biological circulation of matter under the conditions of this region have a relatively closed character. The composition of minor elements which take part in this circulation is determined in the main by the presence of chemical elements in Quaternary deposits which are the parent material.

Received April 11, 1960

BIBLIOGRAPHY

1. GERASIMOV, I. P. 1930. Soil cover of the eastern Ustyurt. Report of soil-botany detachment of the Kazakhstan Exped. of the Akademy of Sciences, USSR. Izd. Akad. Nauk SSSR, vyp. IV, Ch. 1, Leningrad.

2. PEREL'MAN, A. I. 1951. Lime concretions of the Karakum and the Kizylkum. Dokl. Akad. Nauk SSSR, Vol. 78, No. 5.

3. SHUVALOV, S. A. 1949. Question of the complexity of the soil-vegetation cover of Ustyurt. Tr. ses. posvyashch. 100-letiyu so dnya rozhd. Dokuchayeva, izd. Akad. Nauk SSSR.

COMPARATIVE CHARACTERISTICS OF SOD-PODZOLIC FOREST SOILS IN VARIOUS STAGES OF CULTIVATION

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The changes in properties of sod-podzolic soils with their cultivation was studied by many authors. However, the least investigated is the subject of changes in the composition of organic matter in these soils. The papers of Kononova (4, 5), Ponomareva (8), Bel'chikova (1-5), Pankova (5-7), and of others, were devoted to the study of this subject in the northern and central part of the sod-podzolic subzone. The article of Kosheleva and Tolstukhina (6) contain data for the North Taiga and Middle Taiga zones. All the mentioned authors arrive at the conclusion that in the cultivation process of podzolic and sod-podzolic soils occurs in a number of cases a redistribution of the humus content with an increase of the group of humic acids and a decrease of "Fulvic acids."

In this paper, we discuss the change in composition of organic matter with the cultivation of soils of the southern part of the sod-podzolic zone.[1]

The investigations were carried out in 1957 and 1958 on the territory of the sovkhoz Mikheykovo of the Yartsevskiy rayon of the Smolensk Oblast'. The objective was to elucidate the changes in physical-chemical properties of the soils and in the group composition of its humus with cultivation of the soil.

The study of soil cultivation was carried out by comparing soils under forest with treatments in various degrees of cultivation. For this there were selected 4 areas within the boundaries of 1 geomorphological region (a high plain dissected by a network of gullies and ravines) on similar elements of the relief with the same parent material of clay loam.

The soils of the areas are a complex of sod moderately podzolic and sod slightly podzolic coarse clay loams. Soil profiles were taken on each observation area in the sod moderately podzolic soils. The morphological description of these soils is as follows:

Profile 7. Located 1100 m to the west of the southern boundary of Osinovka village under an aspen-spruce forest 30-40 years old. The maximum height of the trees was 16-18 m. The composition of the forest was common spruce — Piceca excelsa (6-7), aspen — Populus tremula (2-3), bearded birch — Betula verrucosa (very little). The understory consisted of Sorbus ancuparia and Corylus avellana. The density of the grass cover canopy was 0.6-0.7. The grasses contained Equisetum silvaticum, Oxaldis acetosella, Geranium silvaticum, and some others. The continuous moss cover contained mosses of the Hypnum type.

A_0 0-5 cm. Forest litter in 3 layers consisting of fallen leaves, branches, and pine needles in various degrees of decomposition.

A_1 5-19 cm. Fresh, light gray, nonstable, crumbly, stratified, medium clay loam, penetrated with roots of trees and grasses. Transition into the following horizon quite distinct.

A_2 19-25 (29) cm. Fresh, pale yellow-gray with scaly plate-like formation, medium clay loam with small pores. Roots are encountered. The thickness of the horizon varies from 3-10 cm. The transition into the lower horizon is distinct.

B_1 29-84 cm. Fresh, brownish cinnamon-brownish color, nutty structured, medium clay loam. Individual structural units are powdered with silica. The horizon is porous. There are occasional roots. Strongly compact. The transition into the lower horizon is gradual in color.

B_2 84-115 cm. Fresh, brownish to cinnamon-brownish lighter colored than the preceding horizon, nutty, porous, medium clay loam, with silica powdering of surfaces of structural units. Individual roots are encountered. The transition to the next horizon is gradual in color.

C 115-150 cm. Somewhat moistened, yellow with a cinnamon-brown shading, porous, medium clay loam, occasional partly decomposed roots.

Profile 6 T. Located 850 m southwest of Kuz'mino village on a slightly cultivated soil. The area is sown to oats (the oats are not thick, and in poor condition).

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[1] The work was carried out in the laboratory of the large scale mapping of the Smolensk soil detachment under the general direction of Yu. A. Liverovskiy and G. I. Grigor'yev.

$A_{1 \text{plowed}}$. 0-17 cm. Fresh, grey, non-stable, crumbly structure, medium clay loam interspersed with roots, transition to the lower horizon is distinct.

A_1 (A_2) B 17-40 cm. Fresh, brownish to cinnamon-brownish, with silica powdering. Occasional white tongues, medium clay loam. Roots are encountered. Transition to the lower horizon is gradual in compaction.

B_1 40-57 cm. Fresh, brownish, stratified, plate-like, medium clay loam with large pores. Silica powdering on individual structural units. Roots are encountered. Transition to the next horizon is distinct by color.

B_2 75-110 cm. Fresh dove-colored, ocherous, non-uniformly colored, stratified, platy, medium clay loam with large pores, silicate powdered on the faces of the structural units. There are no roots. The transition to the next horizon is noted by changes in compaction and in color.

C 110-150 cm. Non-uniformly colored, brown yellowish, medium clay loam, strongly porous with a nutty platy structure.

Profile 5T. Located 800 meters to the southwest of Kus'mino village in a cultivated field. The soil is in a state of moderate cultivation. The crop is oats in good condition. Until 1917 the area was an estate. It was well-manured and limed.

$A_{1 \text{plowed}}$ 0-22 cm. Fresh, dark-grey colored, crumbly to granular structure, friable medium clay loam, interspersed with roots. The transition to the next horizon is distinct.

A_1 (A_2) B 22-24 cm. Fresh, grey brownish to cinnamon-brownish colored, fine nutty, structure medium clay loam. Silica powdering on individual structural units. There are roots. The transition to the next horizon is gradual.

B 34-60 cm. Fresh, brownish to cinnamon-brownish, and somewhat brighter than the previous horizon. Medium clay loam, stratified platy. Silica powdering on the faces of individual structural units. Roots.

B_2 60-120 cm. Fresh, browning, platy, medium clay-loam. Silica dusting on the edges of individual elements of structure. Compact, individual roots. Transition to the next horizon noted by changes in color.

C 120-150 cm. Slightly moistened, yellow, medium clay loam. Poorly developed structure. Below there are signs of slight gleization (dove-colored).

Profile 8T. Located 20 km west of the northern boundary of Kuz'mino village on an area cropped to potatoes. The area has been an estate continuously for the last 80 to 100 years.

A_1 0-24 (27) cm. Fresh, dark-grey, almost black, medium clay loam. The structure is crumbly to granular. An abundance of worm excrements, and of roots. The transition is distinct.

A_1B 24-39 cm. Fresh, brownish-grey, non-uniformly colored, streaked with humus, medium clay loam. Structure is non-stable, crumbly to granular. Interspersed with roots. Slightly compact. There are worm channels. The transition to the next horizon is gradual.

B_1 39-77 cm. Fresh, brownish to cinnamon-brownish medium clay loam, platy to nutty structure with silicon powdering on the faces of structural units. Porous. Roots are found. Transition to the next horizon noticed by change in color.

B_2 77-124 cm. Somewhat moist, brownish-yellow, medium clay loam. Structure is blocky-nutty. Compacted. Transition to the lower horizon noticed by change in color.

C 124-165 cm. Strongly moistened, yellowish-brown, medium clay loam, poorly developed structure.

Soil samples were taken according to genetic horizons. In horizon A_1 (plow) 2 samples were taken — one each from the upper and from the lower parts.

Comparison of morphological characteristics permits us to see how the general character of the soil is gradually changed under the influence of cultivation:

1. With age of cultivation the thickness of the organic horizon A_1 is increased. In profile 7T, it was 14 cm; in profile 6T A_{plow}, it was 17 cm; in 5T A_{plow}, 20 cm; and in 8T A_{plow}, 25 cm.

2. The color gradually changes in horizon A_1 from light-grey to dark-grey. The changes in color of the humus horizon are due to the enrichment with organic matter.

3. With the change in color the structure also changes. In profile 6 horizon A_1 has a non-stable crumbly (and silty) structure. In profile 5 the structure becomes crumbly. In profile 8 the horizon has a well-developed crumbly granular structure.

4. The thickness of horizon in A_2 is decreased. In the forest soil (profile 7) this horizon has a thickness of 8-10 cm. In the slightly and moderately cultivated soil horizon A_2 has a residual character and appears only in the form of whitish spots, lenses, and streaks. In the well-cultivated soil (profile 8) horizon A_2 is absent.

The changes in the morphological characteristics of soils under the influence of cultivation are manifested also in the chemical composition and the particle-size analysis (Tables 1, 2).

The values of the total chemical analysis in Table 1 convincingly show the uniformity of chemical composition of the parent material. At the same time it should be noticed that the total chemical analysis of the upper parts of the profile does not reveal sharp differences between the forest and the cultivated soils with

Table 1

Total chemical analyses of sod-podzolic soils in various stages of cultivation (% of ignited soil)

Profile No.	Horizon	Depth, cm	Hygroscopic water	Ignition loss	Humus	SiO_2	SO_3	P_2O_5	Al_2O_3	Ae_2O_3	CaO	MgO	MnO	K_2O	Na_2O	TiO_2	Sum
7	A_1	5—10	1,41	6,54	2,74	79,26	0,04	0,10	9,36	2,82	1,43	0,85	0,17	4,56	0,71	0,10	99,40
	A_2	22—27	1,25	1,78	0,48	81,48	0,03	0,07	12,65	2.21	1,15	0,73	0,07	1,38	0,55	0,04	100,36
	B_1	40—45	1,82	3,75	0,24	76,82	0,04	0,07	13,40	2,76	1,31	1,20	0,07	3,68	0,72	0,04	100,11
	B_2	85—90	1,80	3,02	0,44	79,04	0,04	0,08	11,38	3,52	1,01	1,15	0,07	3,01	0,75	0,04	100,10
	C	150—155	1,73	2,72	0,75	80,18	0,04	0.13	10,86	3,19	1,15	0,93	0.07	2,96	0.8	0,04	100,35
6	Aplow	0—5	1,3	5,02	1,82	81,55	0,05	0,11	10,09	2,61	1,26	1,10	0,14	2,87	0,44	0,08	100,30
	$A_1(A_2)B$	20—25	2,08	3,49	0,78	78,89	0,03	0,05	15,17	1,46	1,25	0,98	0,07	2,18	0,13	0,03	100,24
	B_1	50—55	1,83	3,42	0,27	79,76	0,07	0,10	13,77	2,57	0,80	0,77	0,07	2,42	0,34	0,04	100,71
	B_3	80—85	1,71	3,24	0,25	79,40	0,07	0,09	11,88	3,16	0,94	0,81	0,07	2,46	0,34	0,04	99,26
	C	150—155	1,74	3,72	0,30	79,28	0,05	0,09	10,83	3.39	1,20	1,01	0,09	3,19	0,17	0,01	99,32
5	Aplow	0—5	1,67	5,72	2,55	80,53	0,07	0,16	11,90	2,82	1,27	1,10	0,15	2,83	0,46	0,08	100,37
	A_1A_2B	25—30	1,43	3,62	0,33	79,80	0,05	0,10	11,70	3,07	1,24	0,97	0,07	2,28	0,34	0,04	99,36
	B_1	40—45	1,89	4,22	0,31	79,42	0,05	0,12	12,05	3,56	0,94	0,90	0,07	2,26	0,27	0,04	99,68
	B_2	80—85	1,73	3,42	0,15	79,31	0,07	0,13	12,97	2,89	1,24	0,94	0,07	2,32	0,32	0,04	100,32
	C	145—150	1,75	3,06	0,46	80,32	0.05	0.08	11,17	2.88	1.23	1,0	0,07	2.33	0,31	0.01	99,45
8	Aplow	0—5	1,72	6,98	3,55	80,86	0,07	0,26	8,98	3,17	1,75	0,93	0,03	2,92	0,72	0,07	100,00
	A_1B	27—32	1,69	4,20	0,61	78,39	0,07	0,16	12,46	3,73	1,17	0,90	0,07	2,01	0,75	0,04	99,75
	B_1	45—50	1,80	3,50	0,34	79,10	0,05	0,14	11,13	3,86	1,38	1,05	0,07	2,80	0,65	0,04	100,53
	B_2	80—85	1,80	3,56	0,29	78,40	0,05	0,10	11,07	3,86	1,46	1,19	0,07	3,62	0,68	0,04	100,54
	C	150—155	1,73	3,30	0,19	78,67	0,05	0,14	11,62	3,85	1,53	0,86	0,09	2,86	0,80	0,02	100,49

Note: Comma represents decimal point.

Table 2

Particle-size analyses by Kachinski's method (in %), analyst G. Berman

Profile No.	Horizon	Depth, cm	Hygroscopic moisture	Loss upon treatment with HCl	Diameter of particles, mm						Sum of particle	
					1,0—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	<0,001	>0,1	<0,01
7	A_1	5—10	1,41	1,49	0,4	13,0	63,0	6,3	5,6	10,3	76,4	22,2
	A_2	22—27	1,25	1,34	0,3	10,5	70,9	6,9	5,7	5,4	81,7	18,0
	B_1	40—45	1,82	2,96	0,2	7,5	59,3	5,1	3,8	22,1	67,0	31,0
	C	150—155	1,73	3,19	None	7,3	64,6	4,8	2,7	17,5	71,9	24,5
5	A_1	0—5	1,67	2,16	0,5	14,0	59,0	4,4	5,0	14,9	73,5	24,3
	A_1A_2B	25—30	1,43	1,37	0,1	9,1	64,7	3,9	3,2	17,6	73,9	24,7
	B_1	40—45	1,89	2,22	0,1	6,0	63,4	5,2	3,0	20,1	69,5	28,3
	C	145—150	1,75	1,97	0,1	3,7	67,6	4,3	4,0	18,2	71,4	26,5
8	A_1	0—5	1,72	3,27	0,9	7,8	62,2	4,4	6,1	15,0	70,9	25,5
	A_1B	27—32	1,69	3,28	0,3	5,9	60,5	5,5	3,5	22,0	65,8	31,0
	B_1	45—50	1,80	2,67	0,1	8,5	57,3	5,1	1,3	24,9	65,9	31,3
	C	150—155	1,73	2,15	0,1	6,0	62,0	8,8	2,4	18,4	68,1	29,6

Note: Comma represents decimal point.

slight and moderate degrees of cultivation. Apparently at these stages of cultivation there is not yet any appreciable change in the total composition of the soil. In a well-cultivated soil (profile 8) there are observed only small increases in the contents of calcium and phosphorus. Therefore on the bases of the total chemical analysis one could conclude all the investigated soils would fall in the same type of sod-medium-podzolic soils.

The particle-size analyses of the soils shown in Table 2 also indicate a uniform composition of parent material in all the profiles. At the same time there are sharp differences in the distribution of the clay fraction along the profile under forests as contrasted with cultivated soil. In the forest soil there is a sharp reduction in the clay fraction in the A_2 horizon and a clearly expressed maximum of this fraction in B_1 (5.9% in horizon of A_2 and 22.1% in B_1 horizon) – This is characteristic for the podzol forming process. In the moderately and well-cultivated soils there is only a weakly expressed maximum content of the clay fraction in B_1 horizon and no sharp reduction in its content in the A_2B horizon. In the cultivated soil as contrasted with the soil under trees there is observed an increase in the clay fraction in A_1 horizon (10.3% in Profile 7 and 50% in Profile 8).

The data of chemical analysis shown in Table 3 indicate that with an increase in the degree of cultivation of the soil its acidity is diminished. Thus the pH (salt) in the forest soil is 4.1; in the well-cultivated soil it is 5.3. There is also a strong reduction in hydrolytic acidity from 8.3 under forests to 1.8 in a well-cultivated soil. Also in cultivated soil this reduction is observed in the entire profile.

Particularly strong are the changes in the composition of exchangeable cations, which occur in the cultivated soil. The sum of exchangeable cations is the same in the forest soil and in the weakly and moderately-cultivated soils. But the composition of the exchangeable cations especially in the upper horizons is appreciably different. In the forest soils the exchangeable hydrogen constitutes 56% of the sum of the exchangeable cations. At the same time its content in the weakly cultivated soil reaches 17%; in the moderately-cultivated soils it does not exceed 3%. In the strongly-cultivated soil the exchangeable hydrogen is practically absent while the contents of calcium and of magnesium increase not only relatively but absolutely. In a well-cultivated soil there is a sharply developed accumulation of exchangeable bases in horizon A_1 (8.9 meq in the parent material, and 18.9 meq in horizon A_1). This, as will be shown later, is due to a change in the direction of the process of humus formation.

The reduction in the value of the exchangeable and hydrolytic acidity with cultivation of soil and concurrent increase in exchangeable bases lead to an ever increasing degree of saturation which in the well-cultivated soil is close to 90%.

Significant changes of chemical indices take place in cultivated soils. In forest soil the amount of readily soluble phosphorus and of exchangeable potassium is low (P_2O_5 – 1.25 mg/100 g and K_2O – 4.9 mg (100 g). In the slightly-cultivated soil the amount of phosphorus and potassium is noticeably increased but still remains low (100 mg/100 g of P_2O_5 and 8 mg of K_2O). Beginning with the moderately-cultivated soil the supply of available P_2O_5 and of K_2O sharply increases to a good level. In a

Table 3

Chemical analysis of sod-podzolic soil in various stages of cultivation

Profile No.	Horizon	Depth, cm	pH		Hydrolytic acidity in meq	Sum of exchangeable Ca + Mg	Degree of base saturation, %	Content of exchangeable cations per 100 g of absolute-dry soil, meq				Composition of exchangeable cations, % of their total cont.			Humus (by Tyurin's meth), %	Hydrolyzed nitro.	P_2O_5	K_2O	Bulk dens. of soil	Humus metric t/hec. in 20 cm layer
			Water	Salt				Ca^{++}	Mg^{++}	H^+	Sum	Ca^{++}	Mg^{++}	H^+		In mg/100 g of soil				
7	A_0	0—5						Not det'd.												
	A_1	5—10	4,7	4,1	8,3	3,2	28	2,2	1,0	4,0	6,2	30,1	13,7	56,2	2,74	4,9	1,25	4,9	1,16	63,56
	A_1	15—19	4,6	4,1	6,4	—	—	—	—	—	—	—	—	—	—	—	1,25	3,7	1,30	—
	A_2	22—27	4,7	4,2	3,0	2,4	44	1,6	0,8	0,70	3,1	51,4	25,7	22,8	0,48	4,2	6,25	2,9	1,31	—
	B_1	40—45	4,7	4,2	4,1	8,0	66	6,8	1,2	1,0	9,0	75,9	13,4	10,7	0,24	5,8	7,5	5,6	1,55	—
	B_2	85—90	4,7	4,2	4,2	6,0	59	4,2	1,8	1,5	7,5	55,9	24,0	20,1	0,44	—	—	4,7	1,55	—
	C	150—155	4,8	4,1	3,0	7,6	72	5,4	2,2	1,0	8,6	62,6	25,5	11,8	0,15	—	—	4,8	1,61	—
6	A_1	0—5	5,0	4,0	4,3	4,9	53	3,9	1,0	1,0	5,9	65,4	17,4	17,2	1,81	10,4	10,0	8,4	1,25	45,5
	A_1	10—15	5,1	4,2	4,3	—	—	—	—	—	—	—	—	—	—	—	10,0	10,8	1,30	—
	A_1A_2B	20—25	5,2	4,3	3,2	7,8	71	6,9	0,8	0,6	8,3	83,0	9,6	7,3	0,79	8,0	12,5	4,6	1,51	—
	B_1	50—55	5,3	4,3	3,6	7,0	66	5,1	1,9	0,7	7,7	66,2	24,6	9,1	0,27	9,9	10,0	4,0	1,51	—
	B_2	80—85	5,2	4,3	4,0	6,7	63	4,8	1,9	1,2	7,9	60,4	24,6	15,0	0,25	—	—	'3,6	1,51	—
	B_3	110—115	5,3	4,4	4,2	—	—	—	—	—	—	—	—	—	0,23	—	—	4,0	1,62	—
	C	150—155	5,3	4,0	3,4	7,5	69	5,4	2,0	0,70	8,1	65,7	25,3	9,0	0,30	—	—	4,8	1,63	—
5	A_1	0—5	5,2	4,4	2,6	8,6	77	7,0	1,6	0,70	9,3	75,5	17,7	0,76	2,55	10,4	25	23,4	1,28	65,28
	A_1	15—20	5,4	4,6	2,9	—	—	—	—	—	—	—	—	—	—	—	15	30,7	1,30	—
	A_1A_2B	25—30	5,9	4,9	1,8	7,4	80	5,5	1,9	0,2	7,6	72,0	25,3	2,6	0,34	8,0	25	30,7	1,43	—
	B_1	40—45	6,2	4,9	2,3	8,2	78	6,0	2,2	0,2	8,4	71,5	26,2	2,3	0,31	7,8	20	28,9	1,52	—
	B_2	80—85	5,3	4,2	2,4	7,3	75	4,9	2,4	0,2	7,5	64,7	32,2	3,1	0,16	—	—	39,1	1,52	—
	B_3	100—105	5,1	4,4	2,1	—	—	—	—	—	—	—	—	—	0,14	—	—	38,0	1,58	—
	C	145—150	5,5	4,4	2,2	7,3	76	3,7	3,6	0,2	7,5	48,3	48,5	3,2	0,46	—	—	37,0	1,60	—
8	A_1	0—5	6,3	5,3	1,8	18,8	91	14,8	4,0	0,1	18,9	78,3	21,1	0,5	3,53	11,5	25	93.9	1,20	85,20
	A_1	15—20	6,2	5,0	1,9	—	—	—	—	—	—	—	—	—	—	—	20	80,6	1,22	—
	A_1B	27—32	5,7	5,0	2,3	13,6	85	6,8	6,8	0,02	13,6	49,9	49,9	0,2	0,60	7,0	25	45,15	1,45	—
	B_1	45—50	5,0	4,4	2,6	12,4	82	7,6	4,8	0,1	12,4	60,8	38,4	0,8	0,34	5,0	25	15,6	1,46	—
	B_2	80—85	5,2	4,2	3,0	9,6	76	5,6	4,0	0,4	10,0	58,4	42,3	0,4	0,28	—	—	44,5	1,60	—
	B_3	124—129	5,2	4,4	3,0	—	—	—	—	—	—	—	—	—	0,18	—	—	81,3	1,62	—
	C	150—155	5,6	4,6	1,6	8,8	84	5,2	3,6	0,1	8,9	58,4	40,4	1,2	0,19	—	—	69,2	—	—

Note: Comma represents decimal point.

well-cultivated soil their supply is high. It is characteristic that the high content of available potassium is noted in the entire profile. Such a considerable quantity of potassium (69-93 mg per 100 g) in the soil of this area can be explained by annual applications of large amounts of manure and of ashes over a long period of time.

The changes in properties of cultivated sod-podzolic soils were noted by a number of authors. The work of Karpinsky (3) who summarized and generalized a large amount of material related to the soils of the Smolensk Oblast' deserves particular mention.

The humus content in the cultivated soil is also noticeably changed. As shown in Table 3, the slightly-cultivated soils have a supply of humus in the 0-20 cm layer which is close to that in the forest soils but in the well-cultivated soil the supply of humus is considerably increased. The least amount of hydrolyzable nitrogen is found in the forest soil — 4.9 mg per 100 g of soil. In the slightly-cultivated and in the moderately-cultivated soils the content of the hydrolyzable nitrogen is 10.4 mg per 100 g of soil; in the well-cultivated it goes up to 11.5 mg per 100 g of soil.

The grouped and fractional composition of humus is shown in Table 4. The analysis of the composition of humus was carried out by Tyurin's method modified by Ponomareva (7). We should point out that the 1-a group of organic matter was extracted by treating the soil with 0.1 N H_2SO_4. Group 1 was extracted by direct treatment of the soil with 0.1 N of NaOH (without preliminary decalcification). This group of organic matter is found in the soil either in free state or in combination with mobile hydrates of sesquioxides. Group 2 is separated only after preliminary decalcification of the soil. Organic matter of this group is usually combined with calcium. Group 3 is separated after treatment of the soil with 1.0 N H_2SO_4 and heating for 2 hours. This group represents polymer complexes which are more firmly combined with stable hydrates of sesquioxides. Carbon is determined in the acid filtrate after hydrolysis for 2 hours.

Considering the data of the group and fraction analyses of the composition of the humus in sod-podzolic soils, one can see that with cultivations there is noted not only an accumulation of humus but a redistribution of its group composition. In the composition of humus of the forest soil the ratio of C of humic acids to C of the fulvic acids equals 0. 7.

In the slightly-cultivated soil which only recently came out from under the forest cover and was subjected to plowing, the humus content is lower than under the forest. Thus the humus content in the upper horizon under forest is 2.74% and in the slightly-cultivated soil it is 1.81%. The ratio of C in humic acids to C in fulvic acids is 0. 6.

In the moderately-cultivated soils the humus content is 2.55% and the ratio of C in humic acid to C in fulvic acid is 0. 9. In well-cultivated soils with a humus content of 3.53% the ratio is 1.1, which indicates conditions favor-

Table 4

Group and fractional composition of humus of sod-podzolic soils in various stages of cultivation (% of total carbon)

Profile No.	Depth, cm	Total organic C	Humus C x 1.724	N, %	C:N	C of alcohol-benzol extract	Humic acids				Fulvic acids						Insoluble residue	C of humic acids / C of fulvic acids
							1	2	3	Sum	1-a	1	2	3	4	Sum		
7	5—10 22—27	1,59 0,28	2,74 0,48	0,09 0,07	17 4	2,51 Not det'd.	13,2 12,1	12,6 3,6	1,3 3,6	27,1 19,3	9,4 15,0	12,6 6,1	13,8 14,3	1,4 3,6	1,2 3,6	38,4 42,6	32,1 38,4	0,7 0,4
6	0—20 20—25	1,05 0,46	1,81 0,79	0,07 0,02	15 23	2,85 Not det'd.	14,3 10,9	9,5 6,5	3,7 3,3	27,5 20,7	0,7 2,2	19,1 15,2	18,7 13,0	3,7 4,3	0,9 4,3	43,1 39,0	26,4 41,3	0,6 0,5
5	0—20 25—30	1,48 0,196	2,55 0,34	0,08 0,02	18 9	4,0 Not det'd.	14,8 10,2	17,6 10,2	2,7 4,6	35,1 25.0	2,0 5,1	17,5 10,2	14,8 22,9	4,0 5,1	0,7 5,1	39,0 48,4	21,8 26,6	0,9 0,5
8	0—20 27—32	2,05 0,35	3,53 0,6	0,24 0,07	8 5	3,9 Not det'd.	11,7 13,7	17,1 9,4	9,3 2,3	38 0 25,4	2,9 12,6	8,8 11,4	12,7 8,0	8,3 4,8	1,6 5,7	34,8 42,0	24,3 32,5	1,1 0,6

Note: Comma represents decimal point.

able to the formation of humic acids in these soils.

Characteristic also is that in well-cultivated soil (Profile 8) the content of carbon in mobile compound in 0.20 cm layer is lowered 11.7% and the quantity of carbon combined with calcium is higher (17%).

As our data show, the processes of humus accumulation and the change of this composition take place in the upper plow layer, i. e., in the layer which is directly subjected to agronomic influence.

Conclusions

1. Under the influence of cultivation sod-podzolic soils gradually loose their original characteristics and acquire new ones. A deep plow layer is created. There is a change in the color of the humus horizon and an improvement in its structure.

2. Along with changes in the morphological characteristics the chemical properties of the soil also change. With slight to moderate cultivations the content of the humus in the soil (in the plowed layer) is reduced as was indicated in the works of Vazhenin (2). However, the amount of humus in the moderately-cultivated soil when computed on the bulk density basis remains unchanged. The total nitrogen content is somewhat increased with cultivation.

At the stage of being well-cultivated, the amount of humus and nitrogen increase considerably and the total content of phosphorus and of calcium is somewhat increased.

3. With the age of cultivation of the soil there is an increase in the exchangeable content of calcium and magnesium, and a decrease in the content of exchangeable hydrogen. The exchangeable hydrolytic acidity is decreased and the degree of base saturation is increased.

At the same time the content of available forms of phosphorus and potassium in the moderately-cultivated soils is greatly increased. The increased content of these forms of phosphorus and potassium in well-cultivated soils is noted over a considerable depth, not only in the A_1 horizon.

4. In the process of cultivation of sod-podzolic soils considerable changes take place in the composition of the organic matter, which is pronounced particularly in the well-cultivated soils. Here, along with an increase in the total content of humus and of nitrogen, there are also changes in the qualitative composition of the organic matter. Humic acids predominate, the ratio of C of humic acids to C of fulvic acids increases from the weakly-cultivated to the well-cultivated and in the latter exceeds unity (1.1). This is confirmed by a considerable accumulation of exchangeable bases in the humus horizon.

Received January 18, 1960

BIBLIOGRAPHY

1. BEL'CHIKOVA, N. P. 1951. Some patterns of the content of humus and properties of humic acids in major soil groups of the USSR. Tr. Pochv. in-ta Akad. Nauk SSSR, Vol. 38.

2. VAZHENIN, I. G. 1957. Chemical characteristics of sod-podzolic soil with various degrees of cultivation and the Kaliningrad Oblast'. Pochvovedeniye, No. 6.

3. KARPINSKIY, N. P. 1940. Characteristics of soils and regionalization of the sod-podzolic zone in connection with the application of chemical fertilizer. Vest. s.-kh. nauki. Agrotekhnika, No. 5.

4. KONONOVA, M. M. 1951. Problems of soil humus and contemporary tasks of its study. Izd. Akad. Nauk SSSR.

5. KONONOVA, M. M., N. A. PANKOVA, and N. P. BEL'CHIKOVA. 1949. Changes in content and composition of organic matter with the cultivation of soils. Pochvovedeniye, No. 1.

6. KOSHELEVA, I. T. and A. S. TOLSTUKHINA. 1957. Cultivation of soil of the northern Oblast' region. Pochvovedeniye, No. 2.

7. PANKOVA, N. A. 1958. Organic matter in sod-podzolic soils and the character of its conversion with their cultivation. In the book: "Plodorodiye dernovopodzolistykh pochv. Moscow.

8. PONOMAREVA, V. V. 1951. New data on the podzol forming process. Vestn. Leningr. un-ta, No. 7.

9. PONOMAREVA, V. V. 1957. Methodology of studying the composition of humus according to the scheme of I. V. Tyurin. Pochvovedeniye, No. 8.

DECOMPOSITION OF PLANT RESIDUES IN THE SOIL

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The formation of organic matter and of available forms, of plant nutrients which enter the soil, are determined by the quality and type of plant residues as well as by character of the processes of its decomposition. It was established that perennial grasses and legumes accumulate considerably more roots and other plant residues than annuals.

The investigations by a number of authors (1, 4, 5, and others) have shown that grasses on the sod-podzolic soils leave from 70-140 cntr/ha of organic residues. Our investigations of the sod-podzolic soils with a 9-year crop rotation in the Kostroma Oblast' showed an accumulation of 84 cntr/ha of living roots in 20 cm after 1 year of perennial grasses. After 2 years the accumulation was 134.1 cntr/ha. Under annual crops the quantity of living roots did not exceed 40-55 cntr/ha.

However, one cannot judge the effects on productivity of the soil only by the amount of organic residue. With the same temperature and moisture, the rate of humification of plant residues of various crops depend on the chemical composition which determines the direction of the microbiological processes. We determined this in the laboratory by comparing the decomposition of plant residues of perennial grasses (roots of clover and of timothy) with that of residues of annual crops (roots of oats).

The experiment was carried out in 0.5 liter glass containers which were filled with 700 g of soil with a moisture content of 22% of absolutely dry soil. Before the containers were filled the soil was sieved through a 3 mm diameter opening screen. The soil, a sod-podzolic coarse clay loam, was taken from a field of the demonstration farm "Zavolzhski" of the Kostroma Agricultural Institute "Karaevo." During a 2 year period the object of the investigation was fields in winter rye undersown with perennial grasses (Field No. 8 in 1958 — No. 7 in 1959). A 5 g sample of chopped-up roots was mixed with the soil in each container. For 4 months the containers were kept in a thermostat with a temperature range of 18-20°C with a soil moisture of 23%. At the end of the experiment the organic content of the soil was determined by Tyurin's method and the nitrates by the colorimetric method. The results are shown in Table 1.

The data in Table 1 show some lack of relation between the content of humus and the amount of nitrates in the soil. The larger quantity of nitrates in 1959 with a lower humus content can be explained by the fact that conditions in 1959 were more favorable for nitrification primarily because of lower acidity. Nevertheless there is a certain regularity in the changes in the quantity of humus and of nitrates over the 2 years which permits us to judge the validity of our data. The data in Table 1 show that the decomposition of perennial grass roots caused an increase in the content of humus and of nitrates while no increase in either was produced by the decomposition of oat roots. Fedorov (9) obtained analogous results in his experiment in which the oat roots accumulated considerably less mineral nitrogen than do timothy or clover roots (204.7 mg; 398.4 mg; and 924.4 mg, respectively). The amount of mineralized nitrogen in the soil depends to a great extent on the amounts and on the ratio of carbon to nitrogen in organic residues. With a low C/N ratio in organic matter there is an accumulation of mineral nitrogen in the soil. On the contrary the wider this ratio, more of the mineral nitrogen is utilized by the microorganisms in building their bodies.

In our experiment with the decomposition of clover roots (with a C/N ratio in organic residue of 10:1-15:1), there was enough nitrogen for the activity bacteria. Part of the organic nitrogen was mineralized and transformed into nitrates. With the oat roots the carbon: nitrogen ratio was wider (C/N = 35:1-50:1). The nitrogen is utilized by the organisms which decompose cellulose and therefore there is no accumulation of nitrates in the soils. An excess cellulose in plant residues, when there is a deficiency of nitrogen in the soil, can retard its decomposition.

At the end of the laboratory experiment we determined the microbiological activity of the soil by adding additional cellulose (filter paper) and observing the decomposition. The soil from each container was placed in a Petri dish. It was moistened and was covered with previously weighed filter paper. After a month the paper was removed, the soil was washed off, the paper was dried and weighed again. The difference in weight before and after the experiment gave the amount of decomposed paper. The following results are shown in Table 2.

Table 1

Effect of organic residues of various plants on the accumulation of humus and of nitrates in the soil

Experimental treatment	Humus, %		Nitrates, mg/kg of soil	
	1958	1959	1958	1959
Control (without addition of roots)	1,9	0,50	17,4	82,8
Roots of perennial grasses (clover and timothy)	2,2	0,55	27,7	185,9
Roots of oats	1,9	0,50	13,1	88,7

Note: Comma represents decimal point.

Table 2

Quantity of decomposed cellulose as a function of the composition of plant residues

Experimental treatment	1958		1959	
	Cellulose	% of control	Cellulose	% of control
Control (without addition of roots)	0,0552	100,0	0,0921	100,0
Roots of perennial grasses (clover and timothy)	0,0413	74,8	0,0787	85,4
Roots of oats	0,0275	49,8	0,0547	59,4

Note: Comma represents decimal point.

The results of this experiment show that e soil in which the oat roots were decom-osed was less active than the soil with per-nnial grass roots. The nitrogen deficiency the first instance had a retarding influence the decomposition process of the added cel-llose.

The factors influencing the decomposition ate of organic residues in the soil are mois-re and temperature which determine the rection and intensity of microbiological proc-sses.

In order to assess the effects of various ombinations of temperature and of soil mois-re on the decomposition rate of plant resi-ues (roots of clover), we carried out the llowing laboratory experiment:

Treatment 1 — The soil temperature was -12°C with moisture contents of: 3.48%; 5%; and 25% by weight of absolutely dry soil.

Treatment 2 — The temperature of the soil as 18-20°C with the same soil moisture of ontents as in the first treatment.

Treatment 3 — The temperature of the soil as 30-35°C and the moisture content as reviously.

The containers were in thermostats during e entire experiment. The moisture was aintained by watering the containers (by eight).

The experiment was carried out in glass ontainers 0.5 liters in volume. The soil was d-podzolic coarse clay loam from a field in winter rye. Five g of air-dry clover roots cut into 0.5 cm lengths were placed in small nylon bags and put into the middle of the containers. After 4 months the bags were taken out, dried, and weighed. The results of the experiment are shown in Table 3.

By comparing the losses in all the plant residues with different combinations of soil temperature and soil moisture one can see that the decomposition of clover roots was least with a soil moisture content of 3.48% (double the maximum hygroscopicity) and a temperature of 10-12°C. With the increase of temperature to 18-20°C and with the same moisture content there is a sharp jump in the decomposition. A further rise in temperature to 30-35°C increases the absolute value of decomposition but its rate is decreased. The same pattern is observed with a moisture content of 15%. With a moisture content of 25% each rise in temperature of 10°C causes a uniform increase in rate of decomposition. Another sharp jump is observed when the moisture content of the soil is increased to 15% when the temperature of the soil is 10-12°C. The increase in soil moisture to 25% at this temperature does not increase the rate of decomposition of plant residues.

The greatest loss in weight of clover roots in our experiment was noted with a soil temperature 30-35°C: it increased uniformly with an increase in soil moisture. The greatest value was reached with a moisture content of 25%.

As a result of laboratory experiment we also established the pattern of microbiological processes of decomposition which was noted by other authors (Vol'ni, Kostichev, and others).

Table 3

Decomposition rate of clover roots as a function of soil temperature and of soil moisture. Loss in wt., % of initial wt.

Moisture, % of absolutely dry soil	Temperature, °C		
	10—12	18—20	30—35
3,48	2,80	28,94	31,42
15,00	22,75	34,60	35,47
25,00	22,36	30,17	38,17

Note: Comma represents decimal point.

The rate and final results of decomposition of organic residues in the soil are strongly influenced by the chemical composition of the plant residues and also by the temperature and moisture of the soil. Comparing long term means of hydrothermic data for the Kostroma Oblast' with the results of laboratory experiments with different combinations of temperature and soil moisture, one can conclude that the most favorable conditions for the decomposition of organic residues exist in the summer months (June-July-August) when the temperature of the soil reaches 15-20°C and soil moisture fluctuates between 5% and 20%.

In the fall (September-October), and in the spring (April-May), the temperature (which does not exceed + 10°C) and the soil moisture (15%-25%) are less favorable for microbiological processes. However, under field conditions the process of humification of plant residues in the fall-spring period proceed with sufficient intensity so that at the time of seeding of spring crops there is noted a decrease of the total amount of organic residues. This is supported by the results of the investigations of I. M. Karasova, assistant to the chair of General Agriculture of the Kostroma Agricultural Institute. These investigations were carried out in 1958-1959 on the Kolkhoz "Mir" of the Nerekhtsk rayon Kostroma Oblast'.

The data in Table 4 show an appreciable rate of decomposition during the fall and spring periods especially with early dates of plowing (September).

In Table 5 are reported observations of the dynamics of organic residues of flax sown in clean fallow after perennial grass sod, which we carried out on an experimental field of the training farm of the Kostroma Agricultural Institute.

It is seen from Table 5 that at the time of seeding of flax the quantity of organic residues was somewhat reduced. This reduction was probably at the expense of small roots which are more easily decomposed. The amount of dead and semi-decomposed residues was increased. The decomposition of organic residues took place primarily in the spring period since in 1958 the plowing was done only 10 days before the soil froze (October 15). It follows that with late plowing the process of decomposition of plant residues in spring months (April-May) proceeds quite intensively. It is necessary to point out that the spring of 1959 was particularly warm. At the beginning of May the temperature of the soil reached 8-12°C. At the time of harvest of flax an accumulation of organic residues was noted. This is accounted for by dying roots, an increase in dead plant residues as well as by the growth of new roots.

On the clean fallow the amount of organic residue in the middle of May was greater than at the time of harvesting of oats, but during June (before manure was applied) there was a sharp reduction of the total amount of residues because of the dead and semi-decomposed residues. Therefore oat residues which contain a good deal of cellulose decompose slowly during the fall-spring period. Their humification proceeds much more energetically during the summer when microbiological processes are undoubtedly affected by cultivation of the clean fallow which makes the soil quite friable.

Thus under conditions of the Kostroma Oblast' the decomposition of plant residues on coarse- and medium-textured sod-podzolic soils can proceed with sufficient intensity not only in the summer but also in the fall-spring period, especially if the plowing is done early. This is observed also in the southern and northwestern parts of the non-chernozem belt. (4.1).

The considerable decomposition rate of plant residues in the fall and spring periods under conditions of the sod-podzolic soils of the Kostroma Oblast' tends to increase the amount of available plant nutrients in the soil but it also has negative aspects. With excess moisture in the soil leaching of readily soluble substances is possible. This can lead to waste of soil fertility accumulated by perennial grasses (especially with early dates of plowing — September). The highest rate of decomposition of organic residues occurs in the summer months. It is therefore necessary to apply organic fertilizer (fresh manure and peat-manure

Table 4

Amount of plant residues in the 20 cm layer of soil in relation to dates of plowing of sod of perennial grasses. The data were given in the report of the department for 1959.

Date of plowing	Content of plant residues, cntr/ha on May 10 of the following year
Sept. 1	42
Sept. 15	66
Oct. 1	100
Oct. 15	106
Nov. 1	150

Note: Comma represents decimal point.

Table 5

Dynamics of organic residues in the plowed layer for various crops

Field No.	Year of investigation	Crop	Time of determination	Total organic residues, cntr/ha	Including		
					Live roots	Dead organic residues	Semi-decomposed
5	1958	Oats	Before seeding May 23	127,3	35,4	28,9	63,0
			At harvest August 22	146,3	44,2	38,1	64,0
	1959	Clean black fallow	May 25	178,3	34,2	66,5	77,6
			Before applying manure July 6	139,3	36,9	42,3	60,1
9	1958	Perennial grasses (clover and timothy second year)	May 15	165,3	113,9	15,1	36,3
			At Harvest August 8	196,4	125,1	21,9	49,4
	1959	Flax after sod	Before seeding May 5	192,0	75,4	41,8	74,8
			At harvest August 17	202,0	47,8	90,8	63,4

Note: Comma represents decimal point.

mixtures) to clean fallow beginning in the fall when the fields are plowed or when it is again cultivated after the sowing of spring crops (May-June). When mixtures of organic and inorganic fertilizer or composts are used they should be applied in the fall, that is, after the second plowing of the fallow or at the time of cultivation if used in place of the second plowing.

Results of laboratory experiments confirm the important effect of the chemical composition of plant residues and also of the temperature and moisture of the soil on their decomposition. However, the dynamics of organic residues and of the rate of decomposition under field conditions suggests the great importance of other factors which were not taken into account in the laboratory experiments.

Conclusions

1. Under conditions of sod-podzolic soils of the Kostroma Oblast' perennial grasses leave a considerable amount of roots rich in nitrogen and have a larger influence on the basic elements of fertility of the soil than do annual crops.

2. When residues of annual crops containing little nitrogen and a lot of cellulose (roots of oats) are decomposed there is a reduction of nitrogen in the soil. With insufficient nitrogen in the soil cellulose retards the process of its humification.

3. Sowing of perennial grasses (mixtures of clover and timothy) is one of the basic methods of increasing the fertility of sod-podzolic soils of the Kostroma Oblast' with organic matter and with mineral forms of nitrogen.

4. The intensity of decomposition of organic residues depends to a great extent on the temperature and moisture of the soil. The summer months June, July, and August are the most favorable with respect to temperature and soil moisture for microbiological processes in the northeastern part of the non-chernozem belt. However, results of the study of the dynamics of organic residues indicate that the process of decomposition is sufficiently intense also in the fall-spring period.

5. The varying degree of intensity of the decomposition process of organic residues during various periods of the year makes it possible to establish: a) the most rational dates of plowing sod perennial grasses; b) the dates and methods and place of application of organic fertilizer and also their type and quality (manure in various stages of decomposition, peat of upper and lower lying bogs, fresh and rotted compost, etc.).

Received December 26, 1959

BIBLIOGRAPHY

1. KASPIROV, A. I. 1959. Roots and harvest residues of annual and perennial crops. Zh. s.-kh. Severo-zap. zony, No. 8.

2. KONONOVA, M. M. 1951. The problem of soil humus and contemporary tasks of its study. Izd. Akad. Nauk SSSR.

3. KOSTYCHEV, P. A. 1949. The soils of the chernozem Oblast' of Russia. Moscow.

4. PANKOVA, N. A. 1958. Organic matter of sod-podzolic soils and the manner of its transformation with the improvement of the soil. In: Plodorodiye dernovo-podzolistykh pochv. Izd. Akad. Nauk SSSR.

5. POSHEKHONOVA, M. I. 1953. The role of the root system of perennial grasses in enriching the soil with organic matter and in formation of structure. Dissertation. Moscow.

6. SIDOROV, I. S. and V. N. KURANOV. 1960. The role of plant residues in soil fertility. In: Nauchno-issled. raboty Kostromskogo s.-kh. in-ta. Kostromskoye izd.

7. SOKOLOVSKIY, A. N. 1956. Agricultural soil science. Moscow.

8. TYURIN, I. V. 1937. Organic matter of the soil. Sel'khozgiz.

9. FEDOROV, M. V. 1955. Microbiology. Moscow.

EFFECT OF PLOWING DEPTH OF ORDINARY CHERNOZEM ON THE ELEMENTS OF SOIL FERTILITY AND ON CROP YIELDS

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At the present time, scientific systems of griculture to insure maximum agricultural roduction with a minimum expenditure of abor and of funds are being worked out for each atural economic zone of our country. One of he most important requirements for the solution of this problem is further increase of the ffective fertility of the soil. Tillage is one f the important methods of increasing soil ertility. Tillage of soil is of particular mportance in the arid and semi-arid regions here such methods of increasing fertility as owing of perennial grasses are not effective rom the economic and agricultural technical iewpoints.

In the total complex of tillage practices directed towards increase in fertility the leading place belongs to plowing. As is known the tudy of plowing depth has a long history. Among the advocates of deep plowing are Komov (5), Volzhanin (1), Shishkin (9), tebut (7), Izmail'skiy (3), Timiryazev (8), nd more recently, Kvasmicov (4), Ivanov (2), and others. Among those opposing it are Ovsinskiy (6), and others. This question is till of great theoretical and practical importance.

To avoid mistakes in developing agricultural systems for one or the other natural conomic zone, all the recommendations must be based on analysis of data from local xperiments. In this connection the question f plowing depth must be resolved on the basis f investigations in the various regions of the one with due consideration of natural conditions.

The authors of this paper are in possession f sufficient long-term material on the study of he depth of plowing on the ordinary chernozem f the southeastern part of the chernozem belt (Kamennaya Step'). In our experiments we ompared the plowing with mold-board plows nd skim-coulters at depths of 22-24 cm nd 30-32 cm. The plowing at a depth of 30-2 cm we shall call deep plowing. The studies were carried out by experimental and field tests nd under practical production conditions on the ields of the Dokuchayev Agricultural Institute f the Central chernozem belt, and on some ollective farms during a number of years beginning in 1949. The area of the experimental plots was not less than 2-3 ha. All the work in setting up the experiments was done at a high level of agricultural practice. The studies were carried out according to the generally accepted methodology. Soil moisture was determined gravimetrically (borings were replicated 3-5 times). Structural composition and water stability were determined by Savinov's method in 3-6 replicates. Nitrates according to Grandval'-Liage. Ammonia was determined with Nessler's reagent on 2 samples composited from 3-5 samples. The yields were determined, as a rule, by harvesting the entire plot with a combine.

Most important in the utilization of deep plowing for increasing fertility is its effect on soil structure. As is known various layers of the organic horizon have unequal content of structural aggregates. On abandoned land the amount of agronomically valuable water-stable aggregates is greater in the upper layers of the soil than in the lower. This is explained by the distribution and the accumulation in the upper layers of the massive roots and the root residues of plants which have a determining effect on the formation of structure and the accumulation of humus. A different picture is observed on land under continuous cultivation. As a result of tillage and the intensification of aerobic processes the structural composition of the plowed layer of the soil is impaired. In the lower layer which is not touched by ordinary tillage the structure is better expressed and is characterized by higher stability. The indicated peculiarity of the various horizons of the soil is confirmed by numerous investigations including our own (Table 1).

The data show that on abandoned land where the soil was never tilled and where the grass is not mowed the sum of water-stable aggregates >0.25 mm in diameter was almost identical in the investigated layers of the soil. However, the agronomically more valuable aggregates >1 mm in diameter were more numerous in the lower layer (30-40 cm) than in the upper. On cultivated fields, even after the sowing of perennial grasses, the total sum of structural aggregates in the 30-40 cm layer was 14%-16% greater than in the 0-10 cm. Attention is called to the sharp increase in content of water-stable aggregates >1 mm in diameter in the lower layer. Therefore, the structural composition of the layer of soil continually under cultivation can be improved by periodically utilizing

Table 1

Amount of water-stable aggregates, %

Depth, cm	Unmowed abandoned land			Field No. 2, perennial grass sod			Field No. 6, continuous cultivation		
	Diameter of fractions, mm								
	> 1	1—0,25	Sum >0.25	> 1	1—0,25	> 0,25	> 1	1—0,25	Sum > 0,25
0—10	77,5	12,7	90,2	16,7	52,9	69,6	8,1	47,5	55,6
10—20	74,5	15,8	90,3	27,4	44,6	72,0	13,6	48,0	61,6
20—30	68,5	20,3	88,8	55,9	23,2	79,1	33,0	38,3	71,3
30—40	63,2	22,9	86,1	54,0	29,7	83,7	—	—	—

Note: Comma represents decimal point.

the structure of the lower lying horizon. This can be accomplished by deep plowing with a mold-board.

Investigations show that increasing the depth of plowing from 20 to 30-35 cm increases the content of structural units in the 0-20 cm layer. Thus, in our experiments in 1951, the sum of water-stable aggregates >0.25 mm in diameter in the 0-20 cm layer was 66% with ordinary shallow plowing, and with deep plowing it was 74.6%. At the same time the more valuable crumbs greater than one millimeter constituted 16.9% in the first instance and 26.8% in the second. Analogous results were obtained in other experiments (Table 2).

One of the properties of the soil which determined the character of the water, air, nutrient regimes is porosity. Soil porosity decreases downward along the profile. The sub-plow layer has a lower porosity than the plow layer. Also with continuous plowing to the same depth a dense plowsole is formed. The "plowsole" and the more dense state of the sub-plow layer impede the penetration of the rain and snow melt water into deeper soil horizons.

Long term observations of the utilization of fall and winter precipitation by the soil carried out at the Dokuchayev Institute of Agriculture of the Central Chernozem Belt, show that water from this type of precipitation is not fully absorbed by the soil. Thus in the fall of 1948 at grain harvest (beginning of August), and before freezing of the soil, 60-62 mm of rain fell in the open steppe. The water content in the 150 cm of soil on oat stubble increased during this period from 393 to 493 mm, i. e., by 46 mm and from 376 to 409 mm, i. e., by 33 mm on plowed-under spring wheat stubble after sod. The coefficient of utilization of fall precipitation ranged from 0.50 to 0.70.

An analogous picture was observed in the fall of 1950. After the harvest of spring wheat (beginning of August), and up to the freezing of the soil, 90 mm of rain fell in the steppe. The moisture content in the two meter layer of soil increased from 457 to 497.9 mm, i. e., by 30.9 mm. In the shelter belt 80.1 mm rain fell and the moisture content increased from 507 to 547.2 or by 40.2 mm. Incomplete utilization of fall precipitation following the harvest period is due to the fact that part of it falls in August and September and is to a great extent evaporated from the surface of the soil. In spite of this the moisture content during the post harvest period (principally in October and November) is notably replenished and the soil retains from 50%-70% of the total amount of precipitation falling during this period. An exception to this are the autumns with large deficiencies of precipitation when the moisture contents of the soil are not replenished and there is a loss through evaporation during the period from harvest of crops to freezing.

Table 2

Effect of plowing depth on soil structure, 1956

Plowing treatments	Sum of water-stable aggregates in layer, %					
	0—10		10—20		20—40	
	> 1 mm	> 0,25mm	> 1mm	> 0,25mm	> 1 mm	> 0,25 mm
To 22—25	7,4	53,6	9,2	61,9	21,2	67,5
To 35	19,5	58,6	21,1	65,1	15,8	61,7

Note: Comma represents decimal point.

In years with normal or nearly normal fall precipitation most of the resulting water is found in the upper friable plow-layer. The distribution of water within the soil prior to freezing could be illustrated by the following examples, from a large number of our observations (Table 3).

The upper layers of the soil (0-5, 5-10, 10-20 cm) were moistened by the fall rains up to a level of close to field capacity, which for these layers is 40%-42%. The moisture content in the 20-30 cm layer is noticeably increased. Lower down along the profile the addition of water from fall precipitation is gradually decreased. At the beginning of the winter soil moisture in these layers never reaches field capacity.

During the winter a certain amount of moisture enters the upper layers of the soil in the form of vapor. Because of differences in temperature the moisture moves between upper layers of the soil and the sub-soil. In the upper part of the soil profile this moisture is condensed and is transformed into ice filling the soil pores. As a result of the entry of fall precipitation into the soil and of the translocation of vapor in the winter, the plow layer is often saturated to a level exceeding field capacity at the time of beginning of snow melt. The high saturation of the upper layers of the soil is one of the reasons for the rather low coefficient of utilization of snow-melt even on fields protected by shelterbelts.

In Table 4 are shown data on absorption of snow-melt water by the soil over a period of years on the cultivated fields in the open Steppe and between the forest shelter belts.

In the majority of cases the coefficient of utilization of winter precipitation by the soil in the fields of the open Steppe ranged from 0.30-0.51. Because of shallower freezing depth of the soil and better structure, a somewhat larger quantity of water is utilized between the forest belts (0.45-0.61).

Therefore, even between the forest belts, from 40%-55% of the water forming by snow-melt runs off or evaporates and is wasted without benefit to agricultural productivity.

In 1949, which was preceded by a rainless fall, 33-35 mm of precipitation fell during the period between grain harvest and freezing of the soil. In this case the coefficient of utilization of winter precipitation sharply increased (up to 0.84-0.89) because most large pores were free of water and of ice crystals.

The character of water distribution in the soil after the snow disappears can be seen in the following example (Table 5).

During years preceded by a fall with normal soil moisture (1948 and 1949), the upper layers of the soil down to 20 cm showed no appreciable increase in moisture content resulting from the melting of snow. Such an increase was most noticeable at the boundary between the plow and sub-plow layers, i. e., in the 20-30 cm layer (plowing was done to a depth of 22-25 cm).

In 1950 when in the fall the upper 20 cm layer of the soil contained much less water than in previous years, snow-melt water was completely utilized by this layer. At the same time this layer was able to pass through it an appreciable amount of water into the lower lying horizons.

On the basis of the foregoing statements one can conclude that for the improvements of the water regime by a more complete utilization of snow-melt, it is necessary to create conditions for the penetration of fall as well as of winter precipitation into the deeper horizons. An important factor is the distribution along the profile of the water resulting from fall precipitation in such a way that its concen-

Table 3

Soil moisture in field No. 1 between forest belts, % of absolute-dry weight

Depth, cm	1947		1948		1949		1950	
	After harvest	Before freezing	After harvest	Before freezing	After harvest	Before freezing	After harvest	Before freezing
0— 5	9,2	43,0	23,6	44,6	10,5	43,8	21,6	41,8
5--10	18,6	48,6	26,2	40,5	20,5	36,6	23,6	40,6
10—20	21,7	37,1	24,3	38,9	22,6	25,2	24,0	40,0
20—30	28,4	27,5	24,7	36,5	21,5	22,6	22,3	34,7
30—40	22,2	22,2	25,6	34,1	21,1	21,8	23,9	23,5
40—50	25,3	18,4	22,6	31,2	21,4	21,4	22,5	20,8
50—60	23,6	17,9	21,5	23,1	22,8	20,3	25,0	22,3
60—70	24,8	17,6	19,5	19,5	18,4	21,1	23,9	19,4
70—80	22,7	18,9	20,0	20,2	16,9	21,5	22,5	19,3
80—90	21,5	17,7	19,7	19,4	17,5	20,8	21,0	18,8
90—100	21,4	17,8	20,2	19,9	18,1	19,8	20,4	18,7

Note: Comma represents decimal point.

Table 4

Utilization of snow-melt water in the 0-200 cm of soil

Years	Field No. 4 in open steppe			Field No. 1 between forest belts		
	Water content in snow prior to melting	Snow-melt water entering the soil	Coefficient of utilization of snow-melt water	Water content in snow prior to melting	Snow-melt water entering the soil	Coefficient of utilization of snow-melt water
	mm			mm		
1947	36,5	23,8	0,51	70,9	43,6	0,61
1948	86,6	33,6	0,39	84,0	51,2	0,60
1949	58	17	0,30	73	32	0,45
1950	86,0	73,0	0,84	81,0	72,0	0,89

Note: Comma represents decimal point.

Table 5

Soil moisture in the fall and after disappearance of snow on Field No. 1 between forest belts, %

Depth, cm	Fall 1947	Spring 1948	Fall 1948	Spring 1949	Fall 1949	Spring 1950
0—5	43,0	47,4	44,6	42,7	43,8	50,1
5—10	48,6	45,4	40,5	42,4	36,6	53,8
10—20	37,1	37,7	38,9	39,7	25,2	52,9
20—30	27,5	38,5	36,5	38,8	22,6	36,9
30—40	22,2	25,8	34,1	32,6	21,8	33,4
40—50	18,4	23,3	31,2	31,8	21,4	35,2
50—60	17,9	22,6	23,1	28 6	20,3	21,8
60—70	17,6	22,8	19,5	23,0	21,1	24,7
70—80	18,3	23,7	20,2	20,1	21,5	21,7
80—90	17,7	23,3	19,4	18,8	20,8	19,7
90—100	17,8	24,9	19,9	18,9	19,8	19,3

Note: Comma represents decimal point.

tration in the upper layers would be reduced. An increase in permeability of the soil in the fall and the spring can be achieved by means of deep plowing. Increasing the depth of plowing to 30-35 cm improves the structure and porosity (in the layers 20-35 cm) and eliminates the plowsole. This insures better penetration of fall precipitation into the deeper lying layers of the soil. At the same time the water content in the upper layers is decreased. To illustrate this we show the results of one of our experiments in 1950 (Table 6).

From the data of Table 6 it can be seen that with deep plowing soil moisture increased inappreciably: this is what should be expected, moisture from fall precipitation on level relief almost entirely enters the soil. Surface runoff during this period is seldom observed on ordinary plowed land. But owing to the deep plowing a redistribution of water has taken place in the soil profile. With deep plowing the moisture content in the lower layer became greater and in the upper layer it became less than with ordinary plowing.

More uniform distribution of moisture in the soil layer, together with the improvement of structure and porosity brought about by deep plowing, insure an increase in permeability. This creates better conditions for the absorption of spring moisture which comes from snow-melt and constitutes a basic amount of soil moisture. According to observations in the spring of 1956 a 50 mm layer of water was absorbed at an average rate of 2.65 mm per minute on ordinary plowed land. On deeply plowed land the rate was 4.15 mm/minute. Deep plowing of clean fallow increased the moisture content of the upper 1 meter layer in the spring of the year by 1.1%-2.4% (Table 7).

The data given in Table 7 show that the same pattern was observed during all years. Deep plowing increased the moisture content in the one meter layer of soil by 150-250 m³ per hectare. In the spring-summer period, soil moisture in the 0-30 cm on fallow land with deep plowing was 1.3% greater than on the control. In the 1 meter layer the increase was 0.6%-1.5% by weight (average for 3 years).

Table 6

Distribution of water in the soil at various depths of plowing before freezing

Depth, cm	Plowing, cm					
	22—24		32—35		22-24 + soil deepener 10 cm	
	%	mm	%	mm	%	mm
0—5	42,9	16,50	38,4	14,79	41,4	16,0
5—10	43,7	16,90	36,9	14,28	39,5	15,25
10—20	34,4	28,29	38,9	32,01	38,0	31,25
20—30	32,9	28,48	37,5	32,47	34,0	29,42
30—40	31,6	27,40	32,7	31,6	32,7	29,03
40—50	30,7	31,66	29,4	30,9	33,4	35,18
Sum	—	149,2	—	156,05	—	156,23

Note: Comma represents decimal point.

Table 7

Moisture of the one meter layer of soil in spring, % of weight of absolute-dry soil

Depth of plowing, cm	1951	1952	1953	1954
20—24	31,7	31,2	29,3	30,4
30—35	32,8	32,2	30,9	32,8

Note: Comma represents decimal point.

It should be pointed out that during the years when there is no spring runoff even on gently sloping land, the moisture content on level deeply plowed land may not be increased. On slopes, deep plowing on the contour, as a rule inhibits run-off. In one of our experiments in 1956 the run-off co-efficient on a 3° slope was 0.31 with ordinary fall plowing, and 0.04 with deep plowing.

Of considerable interest is the effect of the plowing depth on the soil nutrient regime. In ordinary chernozems the humus horizon usually extends to a depth of 60-70 cm. It is known that although the organic matter content decreases with depth, this reduction is not great in the sub-plow layer (20-40 cm). Thus, according to A. S. Baiko the organic content of the soil on one of the fields between the forest shelter belts at the Dokuchayev Institute of Agriculture in the fall of 1949 was: 8.78% in the 10-20 cm layer and 8.17% in the 20-40 cm layer. The corresponding total nitrogen content was 0.45% and 0.413%, respectively. Approximately the same relationship was observed with respect to the mobile hydrolyzed nitrogen determined by the method of Tyurin and Kononova. Its content in the indicated layers was 0.0468% and 0.0462%, respectively. As far as phosphorus is concerned its content in available form in the sub-plow layer was even a little more than in the plow layer.

Therefore, one can conclude that deepening the plow layer to 35 cm does not lower the total content of plant nutrients. However, the sub-plow layer is characterized by a lower biological activity. Microbiological processes which create the available forms of plant nutrients are less intensive in this layer. Bringing up the soil from the sub-plow layer could initially retard accumulation of readily available nutrients because the relative number of microorganisms (aerobes) in the upper layer of the soil would be reduced. In addition, with deep plowing the displacement of the upper, more fertile layer into the bottom of the furrow must insure an increase in the content of plant nutrient in available form in the 20-35 cm layer. This is also encouraged by the increase in porosity and aeration over a greater depth.

Observations on fallow land (when there is no effect of plants) show that at the beginning of the growing season relatively fewer nitrates are accumulated in the 0-20 cm layer when the soil was plowed deeply than when plowed to a depth of only 20-22 cm. However, especially before the seeding of winter crops the nitrate contents in this layer become the same for both depths of plowing. In the 20-35 cm layer more nitrates accumulate with deep plowing. Therefore, in the 0-35 cm layer the accumulation of nitrate with deep plowing is not less and in some cases more than with ordinary plowing. This can be seen from the 1953 data shown in Table 8.

It should be pointed out that in general the process of nitrification in the soil proceeds slowly at beginning of the growing season. This is due to lower temperatures, higher moisture, and insufficient aeration. In this connection it is necessary, even with ordinary plowing, to apply readily available mineral fertilizer before or at the time of seeding in order to improve the plant nutrition conditions.

Fertilizing and early dates of deep plowing can eliminate the possible reduction in accumulation of available plant nutrients in the soil. Deep plowing of fallow for winter crops

Table 8

Contents of nitrates and of ammonia, mg per 1 kg of absolute-dry soil

Treatment	May 6		May 26		June 10		July 7		August 7	
	0—20	20—35	0—20	20—35	0—20	20—35	0—20	20—35	0—20	20—35
Nitrates										
Control	31,6	21,8	19,3	15,6	82,9	46,7	95,4	28,4	303,3	150,0
Deep plowing	23,7	31,9	15,0	12,6	86,5	63,3	244,0	72,5	271,6	176,6
Ammonia[a]										
Control	11,2	11,5	14,1	14,6	9,1	9,2	5,3	4,4	5,7	5,9
Deep plowing	10,7	9,7	14,5	16,2	10,0	9,4	4,4	4,6	8,6	5,5

Note: Comma represents decimal point.

[a] Content of ammonia was the same in both cases.

and late fall plowing for spring crops even without fertilizer do not impair conditions of plant nutrition because a longer period elapses during which biological processes take place which mobilize readily available substances. According to data of other investigators (4.2) the content of available forms of nitrogen and of phosphorus deeply plowed in the soil is not diminished but increased.

The question of the effect of deep plowing on weeds is important. Usually before plowing most of the weed seeds are found in the upper layer of the soil (0-10 cm). With annual plowing to a depth of 20-22 cm the seed is distributed almost uniformly in the 0-20 cm layer. In the case of periodic deep plowing, from time to time part of the seed reaches the layer deeper than 20 cm. The upper part of the plow layer thus becomes less infested. The seeds plowed under to greater depth do not germinate. With subsequent normal plowing they are not brought up to the surface. Thus the infestation of crops is reduced by periodic deep plowing. The same is true with perennial weeds. The vegetative organs of perennial weeds are undercut at a deeper depth and therefore the growth from the roots below the line at which they are cut proceeds slower. In addition roots and rhizomes plowed under to a greater depth produce fewer shoots. The views just expressed are confirmed by the data in Table 9.

According to the observations of D. F. Diezengoff, in our experiment in 1951 the number of stems of sow-thistle in a winter wheat field plowed to a depth of 20 cm was 3.3 per square meter or 30% of the initial infestation. On a deeply plowed area there were only 1.6 stems or 8% of the initial infestation. In 1952 the infestation of sow-thistle was reduced in half by deep plowing.

The increase of the depth of plowing to 30-32 cm increases the yield of a number of crops.

In Table 10 are shown data on yields of winter wheat in relation to depth of plowing of clean fallow.

Deep plowing of clean fallow increased the grain yield over a period of 3 years by 2.4 cntr per hectare on the average. Deepening of the plow layer in early fallow also showed a favorable influence on the yield of winter crops. Thus in "May 1" Kolkhoz of the Tallov rayon the 1952 yield of rye with plowing to a depth of 20-22 cm was 14 centners per hectare. With plowing to a depth of 25-27 cm it was 17 cntr/ha, and with a depth of plowing of 30 cm it was 25.2 cntr/ha. Analogous results were obtained in the Lenin kolkhoz; on an area with ordinary plowing 14.7 cntr/ha of winter wheat were harvested. With deepened plowing the yield was 17.3 cntr/ha.

Deep late fall plowing increased the yield of spring wheat. In our experiments the yield of this crop in 1951 was 13.1 cntr/ha on the control and 14.8 cntr/ha on a deeply plowed field. In 1952 the yields were 9 and 13 cntr/ha respectively. According to our data, millet is quite

Table 9

Amount of germination and weed shoots on 1 m² of fallow in 1953

Depth of plowing, cm	Annuals			Perennials			Total grew
	May 28	June 25	July 15	May 28	June 25	Aug. 15	
22—24	199,1	6,1	2,0	38,0	17,3	8,8	271,3
32—35	183,5	5,1	0,4	22,8	11,9	8,9	232,4

Note: Comma represents decimal point.

Table 10

Yield of winter wheat, cntr/ha

Depth of plowing, cm	Years			Average	
	1952	1953	1954	cntr/ha	%
22—24	16,8	16,1	17,1	16,7	100
30—32	18,8	19,1	19,5	19,1	114,4

Note: Comma represents decimal point.

Table 11

Yield of millet sown as a second crop after deep plowing, cntr/ha

Treatment	Years		Average
	1953	1954	
Control	22,8	8,4	15,6
Deep plowing	25,8	11,2	18,5

Note: Comma represents decimal point.

responsive to the deep plowing (Table 11).

Conclusions

1. With agricultural utilization the structure of the plow layer of ordinary chernozem is considerably worse than that of the sub-plow layer.

2. Fall-winter precipitation even in the forested part of Kamennaya Steppe is not fully absorbed by the soil.

3. One of the reasons for the incomplete absorption of fall-winter precipitation by the soil is the oversaturation of its upper layers resulting from soil dispersion, formation of plowsole, etc.

4. By increasing the depth of late fall plowing from 20-25 cm to 30-35 cm the structure of the plow-layer is improved. At the same time the permeability of the soil is increased. The moisture of fall-winter precipitation is distributed more uniformly along the profile, and the water regime is improved. Deep plowing decreased the weediness of fields. The content of available nitrogen in the plow layer of deeply and ordinarily plowed soils is equalized at the time of planting of winter crops. Deep plowing of fallow and in late fall is conducive to high yields of grain crops.

Received March 3, 1960

BIBLIOGRAPHY

1. VOLZHANIN. 1938. Talks of Petersburg citizen in the ducal agricultural school.
2. IVANOV, P. K. 1953. Methods of creating a deep plow layer in chernozems. sel'khozgiz.
3. ISMAIL'SKIY, A. A. 1949. Selected works. Sel'khozgiz.
4. KVASNIKOV, V. V. 1961. Deep plowing on chernozems, Voronezh.
5. KOMOV, I. M. 1788. Agriculture.
6. OVSINSKIY, I. 1899. New system of Agriculture. Kiev.
7. STEBUT, I. A. 1872. Agricultural notes from a trip through predominantely steppe provinces Russkoye Sel'skoye Khozyaystvo, Vol. 10, No. 2.
8. TIMIRYAZEV, K. A. 1948. Selected works Vol. II Ogiz-Sel'khozgiz.
9. SHISHKIN, N. K. 1876. Reducing the detrimental effect of droughts on vegetation.

EFFECTS OF DRAINAGE ON WATER PROPERTIES OF CLAY AND CLAY LOAM SOILS

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Excessively wet soils constitute about 38% of the entire area of Lithuanian SSR. On the basis of moisture 2 basic types of soil requiring drainage can be designated: A. permanently over-saturated, and B. periodically over-saturated. The principal causes of over-saturation in these soils are the high ground-water level and unfavorable distribution of precipitation during the year. (Mean annual precipitation is 600-650 mm). Excess moisture occurs most frequently in the fall and in the spring, and in the summer during wet years. Regulating the water, air, and nutrient regimes in these soils is possible only by drainage. Therefore, the amount of drainage work in the republic is increasing from year to year. Up to 1959 there were all together 111,400 hectares drained by tile drains. This included 78,615 hectares in recent years (1956-1958). With such rates of development of drainage there is an increased interest in the study of its effectiveness and of the changes that take place in the soil in connection with drainage. Such investigations during the period of 1953-1958 were carried out in the Lithuanian Scientific Experimental Institute of Hydrotechnics and Melioration. The purpose of the investigations was the study of changes in water properties of sod-podzolic gley sod-gley soils on periodically over-saturated cultivated land of the Lithuanian Republic under the influence of melioration practices.

The investigations were carried out on 17 typical sites with clay and clay loam soils in the central parts of the Republic (Central Lithuanian lowlands) with different distances (1, 4, 8 meters) from the drains and on non-drained soils.

Below are given the morphological characteristics of 3 experimental areas. The information is given only for the drained soils as the morphology of the non-drained soils differs little from that of the drained.

1. The Ionishkel'sk Agricultural Tekhnikum (Pasval'skiy Rayon). The experimental area is 25 hectares in size. The soil of the area is a sod gley, leached, fine clay loam on dense nutty clay underlain by a dense calcareous clay loam. Effervescence with HCl occurs at a depth of 60 cm. The area was drained with clay tile in 1931. Distance between tiles is 14 meters. The depth of the tile is 1.2 meters. The entire area was planted to apple trees and in 1954-1956 (the years of the investigation) was sown to perennial grasses — red clover and timothy.

2. Zagrada — a training farm of the Lithuanian Agricultural Academy (Kaunas Rayon). The experimental area of 11 hectares has a southward slope of 1.7%-1.8%. The prevailing soil is a sod-podzolic gley sandy-loam underlain by a fine clay loam. The area is stratified with soils of finer texture which have 2 components (for instance coarse clay loam on clay). Gley is noted at 75 cm. The clay tile is at depths of 120-, 80-, and 60-cm with the distance between drains ranging from 8-32 meters. The area was first drained in 1951. In this paper are shown the results of the investigation on only that part of the drainage system where the tile is at a depth of 1.2 meters. Over an 8 year period beginning in 1952 the experimental area was in grain and in root crops.

3. The "Zhdanov" kolkhoz (Kedayn Rayon). This area is typical of the majority of the soils of the Central Lithuanian lowlands. The area is on a gently undulating plain with microrelief. (Differences in elevation up to 10-30 cm).

The soil is sod-gley leached sandy-loam. It is very dense at a depth of 60 cm. The gley is observed in the sub-plow horizon. Effervescence with HCl occurs at a depth of 40-50 cm.

The area was first drained with clay tile in 1931. Distance between drains is 16-32 meters. The depth of the tile is 10-120 cm.

The particle-size analyses of the soil of all 3 areas at a distance of 1-8 meters from the drains are shown in Table 1.

The investigations carried out by us showed that drainage has a definite effect on the physical properties of the soil. The effect of drainage is expressed in: lowering of the ground-water level; improvement of filtration; changes in moisture content; aeration; and in other properties of the soil.

Drainage immediately produces a lowering

Table 1

Particle-size analysis of soils (by N. A. Kachinskiy's method)

Place	Distance from drain, in m	Horizon	Depth, cm	Loss in treatment	Skeleton 10-1 mm	Diameter of particles, mm						
						1—0,25	0,25—0,05	0,05—0,01	0,01—0,005	0,005—0,001	< 0,001	Sum < 0,01
Ionishikel'sk agricultural tekhnikum	1	A	10—20	2,4	—	1,7	20,5	28,0	20.4	16,8	12,6	49,8
		AB	20—30	3,4	—	1,6	8,3	22,1	24,5	26,4	17,1	68,0
		B	50—60	21,4	—	0,3	25,7	4,8	12,1	30,5	26,6	69,2
		C	80—90	22,5	—	0,2	19,1	5,7	13,7	22,1	39,2	79,0
	7	A	10—20	2,8	—	1,4	19,3	26,0	21,2	19,0	13,1	53,2
		AB	20—30	3,4	—	1,3	13,5	18,2	18,2	18,9	29,9	67,1
		B	50—60	23,3	—	0,1	18,8	19,2	9,1	12,1	40,7	61,9
		C	80—90	21,3	—	0,2	21,0	6,5	16,0	19,9	36,4	72,3
"Zagrada"	1	A	10—20	2,6	0,8	2,7	47,1	31,2	5,2	8,6	4,4	18,2
		A_2B	25—35	2,9	—	1,5	42,2	36,4	3,0	4,8	12,1	19,9
		B	50—60	4,7	0,9	7,0	35,5	13,5	4,5	12,4	26,2	43,1
		C	80—90	19,3	5,3	5,3	36,7	11,2	4,6	13,4	23,5	41,5
	12	A	10—20	2,7	1.3	3,2	41,9	33,4	2,7	9,2	8,3	20,2
		A_2B	30—40	2,6	0,3	3,0	28,6	48,9	5,5	2,3	10,4	19,2
		B	50—60	5,0	0,2	6,3	23,3	16,3	4,3	13,6	36,0	53,9
		C	80—90	3,9	1,1	9,4	37,1	8,6	6,7	11,2	25,9	43,7
Zhdanov Kolkhoz	1	A	0—15	0,5	1,2	6,8	59,6	16,7	3,2	8,3	4,2	15,7
		B	30—40	17,1	10,6	8,6	42,2	18,1	2,7	6,3	11,5	20,5
		BC	50—60	12,4	1,6	8,9	54,9	10,6	3,1	9,8	11,1	24,0
		C	80—90	19,7	19,7	4,7	48,9	16,2	2,4	3,0	5,1	10,5
	16	A	0—15	0,6	1,4	4,4	54,1	20,3	5,4	5,6	8,8	19,8
		B	30—40	7,2	10,5	1,4	50,4	18,8	4,7	6,8	7,4	18,9
		BC	50—60	11,2	3,7	11,3	53,4	11,0	3,9	6,6	10,1	20,7
		C	80—90	11,3	10,5	3,0	62,5	15,1	2,3	3,1	3,5	8,9

Note: Comma represents decimal point.

Table 2

Physical properties of the soil

Place	Depth, cm	Particle density[a]	Bulk density, g/cm³			Porosity %		
			Distance from drain, m					
			1	4	8	1	4	8
Ionishikel'sk agricultural tekhnikum	10—20	2,51	1,40	1,45	1,48	44,3	42,0	41,0
	30—40	2,52.	1,55	1,52	1,62	38,5	37,0	35,6
	50—60	2,63	1,48	1,58	1,63	43,5	40,0	38,0
	80—90	2,65	1,52	1,64	1,75	42,6	38,0	34,0
"Zagrada"	10—20	2,51	1,37	1,35	1,34	45,2	46,0	46,0
	25—35	2,56	1,53	1,53	1,53	40,0	40,0	40,0
	50—60	2,58	1,52	1,62	1,62	41,0	37,0	37,0
	80—90	2,59	1,65	1,70	1,75	36,2	34,3	32,5
Zhdanov Kolkhoz	10—20	2,52	1,23	1,34	1,37	51,0	46,5	45,5
	25—35	2,61	1,65	1,66	1,71	36,5	36,4	34,5
	50—60	2,66	1,68	1,74	1,77	37,0	34,5	33,3
	80—90	2,74	1,84	1,86	2,00	32,7	32,0	27,0

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[a] Average values are used since the drain has no effect

Note: Comma represents decimal point.

of the ground-water level but initially the action of drainage is less intensive than in subsequent years. On drained fields the ground-water levels are lowered sooner in the spring and the soil dries out earlier.

From Table 2 it is seen that the bulk density and porosity of the soil is changed over a considerable range depending on the texture. For the clays (Ionishkel'sk Agric. Tekhnikum) the bulk density increases and porosity decreases with distance from the drains. For clay loams this is less pronounced. Ground water near the drains is lowered quicker than between the drains. Figure 1 shows the lowering of the water level in the spring of 1955 at different distances from the drain on the area of the Ionshkel'sk Tekhnikum, of Zagrada, and of the Zhdanov Kolkhoz.

On the clay soils the ground-water level at a distance of 1 meter from the drain is lowered to a depth of 40 cm[1] in the spring of the year. This lowering occurs approximately 3-5 days sooner than at a distance of 4-7 meters from the drain. On clay loams the ground-water level is lowered about 10 days earlier at a distance of 1 meter from the drain than at a distance of 4 meters. The difference in the rate of lowering at distances of 4 and 8 meters is 3 days. At a distance of 8 and 12 meters from the drain there is almost no difference in the lowering of the ground-water level (Zagrada). On coarse skeletal clay loams and on sandy loams (the Zhdanov kolkhoz) ground-water level at a distance of 1 meter from the drain does not rise to 40 cm. It should be pointed out that with high ground-water levels the effect of the distance from the drain is greater than with lower ground-water levels. In general on drained land the ground-water level is lowered 31 days sooner on fine-textured soils. On coarse-textured soils the difference is 23 days.

The quicker lowering of ground-water levels near the drains is explained by the higher hydraulic gradient, better permeability, and by the effect of the drain on other physical properties of the soil.

The coefficient of filtration in the sub-soil horizon was determined by Nesterov's method (Table 3). The highest filtration was observed on coarse skeletal clay loam (Zhdanov kholkhoz). According to Krivonosov (2), the determining role here belongs to the texture of the soil. However, the coefficient of filtration is greater on drained areas (approximately 1 1/2-3 times) than on undrained soils. On the uniform fine-textured soils (Ionishkel'sk Tekhnikum) the coefficient of filtration does not appreciably decrease with the distance from the drain. At a distance of 4 meters from the drain it was reduced 20%-35% and at a distance of 8 meters, 50%-70% in comparison with the coefficient of filtration near the drain (1 meter).

With increase in depth the coefficient of filtration of undrained soil has decreased more rapidly than that of drained soil (Table 4). If we take the coefficient of filtration of a drained field as 100% for each horizon then the coefficients for an undrained field would be: 34% for the plow layer; 21% for the sub-plow layer-horizon A; 7% for horizon B, and 2% for horizon C.

Along with the coefficient of filtration we

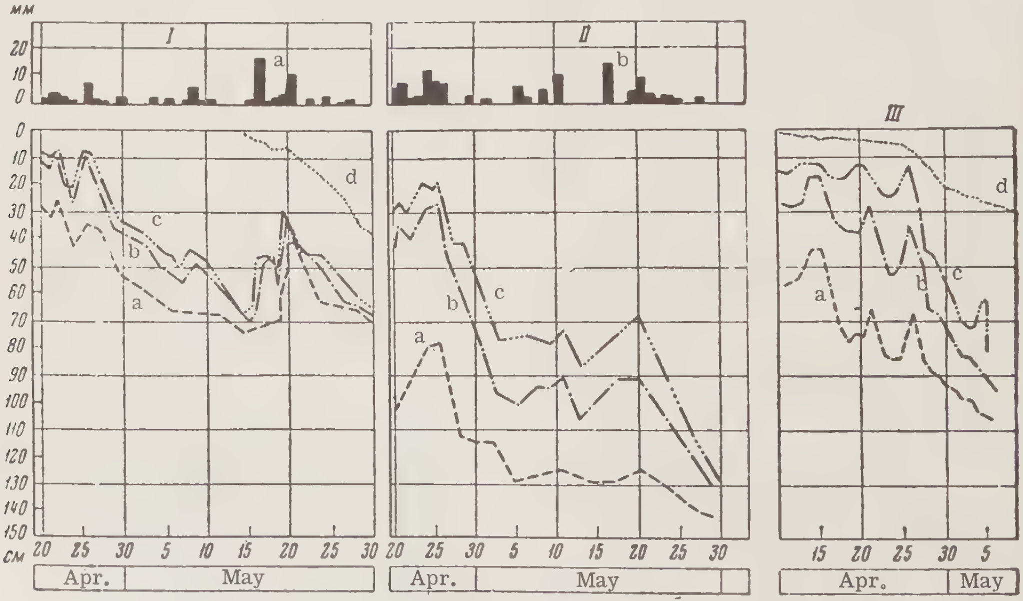

Fig. 1. - Ground-water level.

I - Ionishkel'sk agric. tekhnikum; II - Zagrada; III - Zhdanov kolkhoz. a - 1 m from drain; b - 4 m from drain; c - 7-8 m from drain (zhdanov kolkhoz 16 m); d - undrained; e - precipitation.

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[1] A depth of ground water at which field work can start in the spring.

Table 3

Coefficient of filtration, cm/sec (all values are multiplied by 10^4)

Place	Distance from drain, m			Not drained
	1	4	8	
Ionishikel'sk agricultural tekhnikum	7,13— 1,13	5,66—1,7	3,41—0,57	0,3 —0,06
"Zagrada"	5,53— 3,39	5,10—2,27	3,48—1,20	2,26—0,32
Zhdanov Kolkhoz	19,2 —10,8	11,3 —7,4	11,3 —4,3	5,6 —3,4

Note: Comma represents decimal point.

Table 4

Coefficient of filtration in cm/sec at various depths (Zhdanov Kolkhoz) (values of c. of f. multiplied by 10^4)

Horizon	Depth, cm	Drained	Not drained
A	10—20	90,0	12,8
B	30—40	8,57	1,77
BC	50—60	5,34	0,354
C	80—90	3,23	0,072

Note: Comma represents decimal point.

observed the absorption rate of the soil. On the drained soil, especially near the drain, the soil absorbed the water considerably faster than it was filtering through. On fine-textured soils (clay and clay loam) the water was absorbed twice as fast at a distance of 1.4 meters from the drain as at a distance of 8 meters and 4-5 times faster than on an undrained area. On the coarse skeletal clay loams the water was absorbed from 4-6 times faster than on clay soils, therefore here the drain has less effect. Eight meters from the drain and on the undrained field the water enters the soil only 2-3 times slower than 1 meter away from the drain.

In one case (on clay) a determination of filtration and of absorption was made by artificial flooding. The plow layer was not removed. At different distances from the drain the soil absorbed water quite differently. At 1 meter from the drain the rate was 150 liters per hour, at 8 meters 60 liters per hour, and on the undrained soil, 7 liters per hour. The observations showed that the absorption capacity of undrained fine-textured soils is quite inappreciable. As a result water is retained for long periods of time until it is evaporated. Water logging occurs on appropriate elements of relief. Structural aggregates of the soil are softened and disperse and when the soil dries out it cracks and tears the small roots of plants. This does not occur on drained soils with increased water absorbing capacity and increased infiltration.

On drained fields with improved infiltration properties fluctuations in soil moisture during the growing period are less than on undrained soil. Determination of soil moisture during the growing season (April-September) in "Zagrada" were made every 10 days in each of the following horizons: A — 10-20 cm, A_2B — 25-35 cm, B — 50-60, and C — 80-90 cm. This was done over a period of 3 years (1953-1955). The year 1953 could be considered normal with respect to the amount and distribution of precipitation. 1954 was a wet year and 1955 was dry.

In years with precipitation close to the average and in wet years soil moisture was increased with the distance from the drains. Soil moisture in 1953 is shown in Figure 2. With the distance from the drains the moisture changes as follows (Table 5).

If at a distance of 1 meter from the drain the soil moisture is taken as 100%, then at a distance of 12 meters the moisture in the plow layer was greater by 4%-13%, and in the sub-plow horizon by 28%. In dry years the soil moisture increases with the distance from the drain in upper horizons and decreases in the lower horizons. In the sub-plow horizon between the drains it is 12% less. Near the drain the fluctuations in soil moisture are inappreciable during any year. With the distance from the drain fluctuations increase. In the plow layer the fluctuations of soil moisture are greater than in the subsoil horizon. The deviations from the normal values of moisture for years with average precipitation are greater in dry years than in wet years. They are also smaller near the drain than between the drains. This is explained by the fact that in wet years drainage removes the excess moisture and in dry years it is not able to accumulate as much moisture as the plants require.

Investigation of the capillary and of the total moisture holding capacity shows that with the distance from the drain the capillary and total moisture holding capacity decrease. The effect of drainage does not extend to the maximum hygroscopic moisture of the soil which is essentially dependent on the texture of the soil and on the amount of humus. Therefore, the wilting moisture on drained soil and on undrained

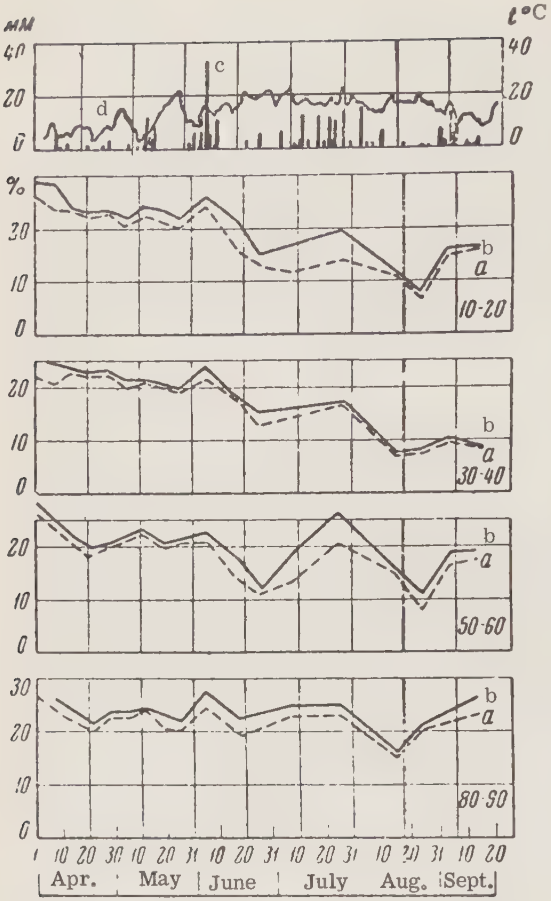

Fig. 2. - Soil moisture, 1953.
a - 1 m from the drain; b - 12 m from drain; c - precipitation; d - temperature, °C.

Table 5

Soil moisture at various distances from the drain (average for 6 months) in % of absolute-dry weight

Horizon	Depth, cm	Distance from drain, m		
		1	8	12
A	10—20	22,6	23,5	25,5
B	50—60	18,9	21,1	24,1
C	80—90	20,2	23,7	23,6

Note: Comma represents decimal point.

soil are nearly the same (Table 6).[2] Drained soils, because of increased porosity and accumulating capacity, have more productive moisture (available to plants) than do undrained soils.

Aeration of the soil is closely related to its moisture. With an increase in moisture there is a decrease in the amount of air in the soil and vice versa. The optimum water-air regime is one where 25% to 45% of the pores in the soil are filled with air (3). Such a ratio of water to air is observed only in a structural soil. On drained areas a granular soil is created with appropriate tillage. The relationship between moisture and air in such soils is especially favorable.

Our observations show (Fig. 3) that the maximum amount of air in the soil is found

Table 6

Maximum hygroscopicity of drained soils

Place	Depth, cm	Maximum hygroscopicity, %		Wilting moisture	
		Distance from drain			
		1	8	1	8
Ionishkel' agricultural tekhnikum	10—20	6,1	5,8	9,15	8,7
	30—40	9,2	7,2	13,80	10,80
	50—60	8,9	8,1	13,35	12,15
	80—90	9,1	8,1	13,65	12,15
"Zagrada"	10—20	2,14	2,15	3,21	3,23
	25—35	3,42	3,54	5,13	5,31
	50—60	5,69	5,43	8,55	8,15
	80—90	3,82	3,76	5,73	5,64
"Zhdanov" kolkhoz	10—20	4,70	5,82	7,05	8,88
	25—35	5,65	4,30	8,48	6,45
	50—60	4,86	4,20	7,29	6,30
	80—90	1,39	4,71	2,09	7,07

Note: Comma represents decimal point.

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[2] The wilting moisture was computed from maximum hygroscopic moisture by multiplying it by 1.5 (1).

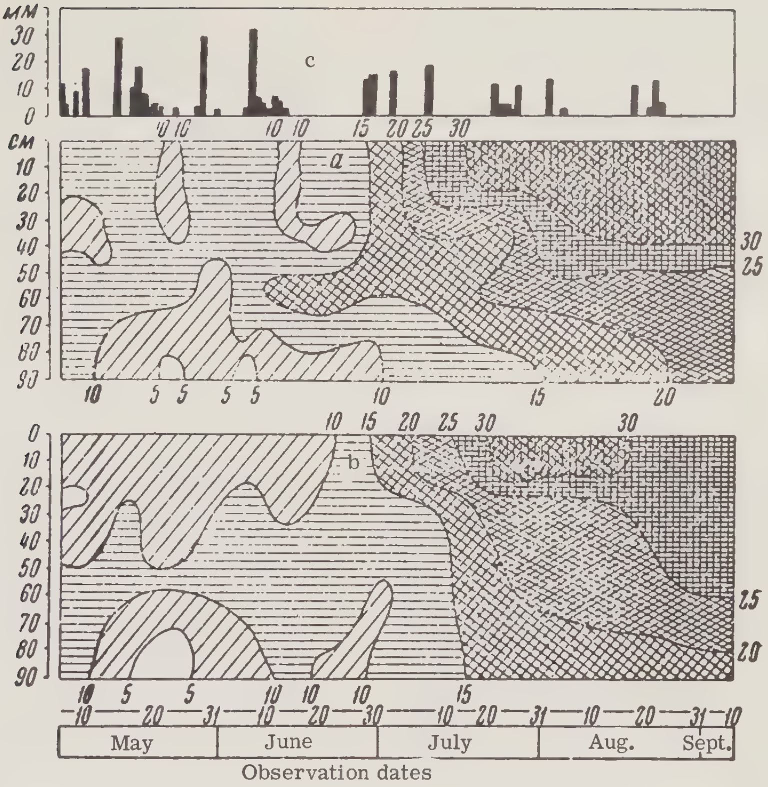

Fig. 3. - Aeration of soil, 1955

a - 1 m from drain; b - 12 m from drain; c - precipitation.

Table 7

Yields of grain crops

Yield	Distance from drain						Undrained	
	0—4		4—8		8—12			
	Total	Grain	Total	Grain	Total	Grain	Total	Grain
In cntr/ha	58,3	23,6	52,6	21,3	51,3	21,0	47,0	19,2
In %	100	100	90,5	90,5	88,5	89,0	80,7	82,5

Note: Comma represents decimal point.

near the drain. With distance from the drain the air content is reduced. In dry periods the air content of the soil at a distance of 1 meter from the drain in the plow layer even exceeds the optimum (more than 50% of the pore space). During rainy periods the amount of air in the soil near the drains is sufficient; in the center between the drains a deficiency of air is felt. In the undrained soils the amount of air is very small. Comparing data for wet and dry periods one can see that in all cases more favorable conditions for the development of agricultural crops are created near the drains. Drained soils can withstand droughts better not only because of their better structure but also because they can absorb even small quantities of precipitation. During wet years the excess moisture is removed by the drains and the ratio of water to air approaches the optimum.

On drained fields because of improved physical properties of the soil it is possible to produce high and stable yields of agricultural crops. The data of grain yield (average for 5 years in "Zagrada") are shown in Table 7.

From the data on Table 7 it can be seen that with the distance from the drains yields are reduced in the middle by as much as 11%. On the undrained field which is located next to the drained one, the yield is reduced by 18%. In most locations in the Republic the yields of grain on drained soils is generally 4-8 cntr/ha higher than on undrained soil.

Received May 25, 1959

BIBLIOGRAPHY

1. BYALYY, A. M. 1957. Soil moisture at wilting of Plants. Pochvovedeniye.
2. KRIVONOSOV, I. M. 1925. Drainage of slowly permeable clay soils. Gidrotekhnika i Melioratsiya, No. 10.
3. RAKTANEN, L. S. 1956. Questions of soil porosity. Tr. Kishinevsk. s.-kh. in-ta.
4. RODE, A. A. 1955. Water properties of soils.

DETERMINATION OF MOISTURE OF FRIABLE SUBSTANCES BY ELECTRO-CONDUCTIVITY

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In the investigations of the kinetics of the process of wetting or drying of a moist soil, and of the laws governing the movement of water in the soil, it is necessary to consider the distribution of temperature and moisture in the soil over small periods of time. The measurements of temperature at any soil depth are successfully accomplished with thermocouples and by other means. The measurement of moisture content on the other hand is rather difficult. The more reliable method — taking of samples and subsequent determination by means of drying — is not applicable in this case because it is quite difficult to take samples concurrently at several points. The taking of samples inevitably leads to destruction of the structure of the soil layers and therefore to changes of all subsequent physical processes.

The most convenient and rapid electrothermal method was used by many investigators to determine moisture of soils and of other capillary -porous and colloidal-capillary-porous substances (2, 4, 6). Special investigations directed toward developing a reliable quick method for determining moisture were carried out by Dolgov (3), Sozykin (7), and by others including foreign authors (9, 10).

The majority of papers on the determination of moisture content of soils by measuring its electrical conductivity pay a great deal of attention to all the factors that affect electrical conductivity. However, the dependence of the electrical conductivity of a wet soil on temperature was not sufficiently investigated. Some authors assume this relationship to be linear. Others compensate for temperature by special arrangements (2), or by correction coefficients (7). Some do not consider it at all (8).

In attempting to investigate the relationship between the electrical conductivity of a moist soil and its properties, condition and its state, we endeavor to establish the relationship of electrical conductivity (electrical (Ohm) resistance) of the soil on its moisture at a constant temperature. The measuring apparatus was assembled on the base of a UN-2 bridge. The specially constructed cells consisted of small trielectrode devices 20 mm long spaced 10 mm apart. The experiments were carried out principally in unwashed unsieved lyuberetzk quartz sand. The experiment began with the preparation of the sample. Sand with a given moisture content was placed in small amounts in a metal cup with an insulated inner surface. The cell was placed in the central part of the cup. Constant density of the sample was maintained by means of a constant load. To maintain constant moisture in the cup, it was plugged with a rubber stopper sealed with Mendeleev putty and covered with a lid. One thermocouple was placed with the cell in the center part of the sample; another pair was placed at the inside surface of the cup. That was done in order that the measurements of the electrical conductivity could be made after uniform heating of the sample. At the end of the measurement samples were taken to determine the moisture content. The results of one such experiment are shown in Figure 1-A in the form of an isothermic curve corresponding to a temperature of 26°C.

Later a series of cells were constructed which were carefully checked for identity of readings in the same sample. Thirty cups with samples having different moisture content — from air-dry states to total water holding capacity were placed in a thermostat with an accurate regulation of temperature. The leads from the cells and thermocouples were connected to appropriate recorders through switches. After the thermostat reached the required temperature the uniformity of heating of the samples was determined by readings of the thermocouple and measurements of resistance were made. The data of one such experiment are shown in Figure 1A. On the ordinate are given the moisture content in the sand in percent, on the abscissa which has a logarithmic scale are given the resistances in kilohms. Isotherms obtained in this manner for each 10 degrees fall quite regularly with respect to each other, for moisture contents greater than 3%. For lower moisture contents they are approaching asymptotically the X axis and coverage into one line. These results agree well with the results of Sozykin's (7) experiments.

Further investigations were carried out with the aim of a more detailed study of the electrical conductivity of the material and of the properties of the adsorbed moisture when the moisture content of the sample is low. It is known that the energy of molecular and heterpolar connection and of electrical resistance (R) of the sample decrease with increase in temperature, but the laws governing these changes are not known. One can only assume that the change in electrical conductivity would be different for

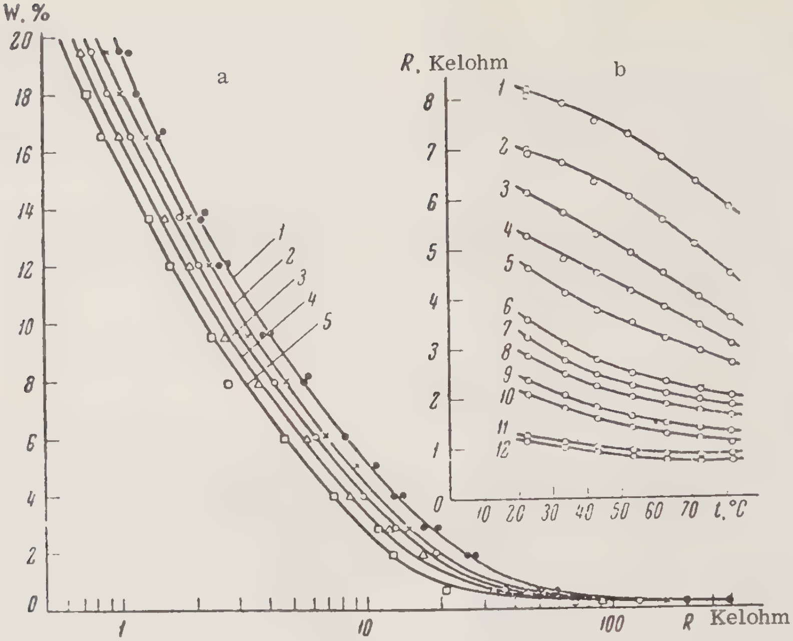

Fig. 1. - Relation of electrical resistance of Lyuberetzic sand to moisture - A and to temperature - B.
Curves Fig. A for temperature: 1 - 26°C; 2 - 38°C; 3 - 48°C; 4 - 58°C; 5 - 68°C. Curves Fig. B for moisture of sample: 1 - 0.36%; 2 - 1%; 3 - 2%; 4 - 2.9%; 5 - 4%; 6 - 7.2%; 7 - 8.3%; 8 - 10.4%; 9 - 14.5%; 10 - 15.5%; 11 - 18.3%; 12 - Full moisture holding capacity.

different forces and for different forms of bonds between the moisture and the substance. The experiment confirmed this assumption. On Figure 1-B are shown the relationship between electrical conductivity and temperature for samples of Lyuberetsk sand with various moisture contents. It is clearly seen that with very low moisture content (from 0.36%-2.0%) the curves are placed with their convex part toward the high resistances, i.e., the reduction in resistance per degree increases with increase in temperature. With higher moisture contents (greater than 3%) the curves lie with the convex part toward the low resistances, i.e., the reduction in resistance per degree is reduced with increases in temperature. The point of separation between these 2 relationships is a straight line corresponding to a moisture content of 2.9%. One can therefore consider that for Lyuberetsk sand a moisture content close to 3% is a limiting one. With lower moisture content the adsorbed moisture in the pores of the sand experiences a greater action of molecular and other forces and has properties different from the moisture at moisture content of the sand greater than 3%, a point at which the moisture can be considered free. For other soils having a different porosity and a different colloidal content, this boundary between different properties would be changed.

The relationship of electrical conductivity on moisture content and temperature of the material was the basis for constructing a moisture cell. Knowing the temperature and the electrical conductivity in a given point of a sample it is possible to determine the moisture content from a graph, if other factors (density, contact of the cell with the material, presence of salts, and others) remain constant.

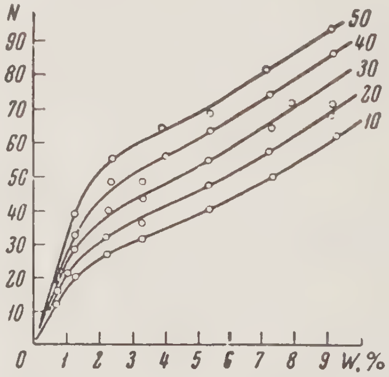

Fig. 2. - Rating curve of the device. Numbers on the curves indicate temperatures.

The scheme of the constructed apparatus differs little from the salt-meter described in the paper by Berliner and Dolgopolov (1). We utilized as they did the compensation principle of 2 contours having a common link into which is introduced a galvonometer which permits readings of electrical conductivity. The divisions on the scale (N) are directly proportional to the electrical conductivity of the material. The device is fed through a voltage stabilizer. The cells are the same as referred to before. The rating curve of the device built for Liuberetzk sand is shown in Figure 2. On the abscissa are given the moisture of the sand in percent, on the ordinate the electrical conductivity in readings on the scale (N).

Isotherms obtained for each 10 degrees and covering a large interval of moisture show a definite regularity of the change with the increase of temperature. With a moisture content greater than 3% they are almost parallel. For low values of moisture they converge to zero forming a cluster of lines each of which has a greater angle than the one for higher moisture content. Similar bending of the lines was noted in the rating curves in Sizyakova'a paper (6), and in papers of other investigators who studied electrical-conductivity of moist dispersed material. With increase in temperature the bending of the isotherm is clear and shifts toward the side of lower moisture. Thus with a temperature of 50°C the bending of the isotherm is observed in our experiment when the moisture content of the sample is 1.75%. This again confirms the conclusions about difference in properties of observed moisture and about the existence of a limiting moisture content.

The described device was used quite successfully in the study of movement of vapor moisture in soil models (5).

Received February 17, 1960

BIBLIOGRAPHY

1. BERLINER, M. A. and N. I. DOLGOPOLOV. 1954. Electrothermal determination of salt content of soils, ground and of ground-water. Izd. -vo Akad. Nauk SSSR.

2. DUBNITSKIY, V. I. 1952. Investigation of moisture of thermo-insulation and thermo-conductors. Report VFTI, Fondy, Vses. teplotekhn. in-ta.

3. DOLGOV, S. I. 1937. Relationship between electro-conductivity of soil and its water content. Soil Physics. Izd. VASKhNIL, Moscow.

4. LYKOV, A. V. 1938. Kinetics and dynamics of processes of drying and wetting. Gizlegprom., Moscow-Leningrad.

5. ONCHUKOV, D. N. 1955. Investigation of heat and moisture transfer in soils and grounds. Dissertation MTIPP. Fondy Mosk. tekhnolog. in-ta pishch. prom.

6. SIZYAKOVA, YE. I. 1951. Investigations of thermal and moisture conductivity in capillary-porous substances. Dissertation MTIPP. Fondy Mosk. tekhnolog. in-ta pishch. porm.

7. SOZYKIN, N. F. 1941. The contact method of determining soil moisture. Tr. VNII lesn. kh-va, vyp. 24, Izd. VNIILKh.

8. CHERNAYAK, G. YA. 1952. Electrothermal investigation of moist soil. Dissertation VNII. Fondy Vses. n. -i. in-ta Vodgeo.

9. HEINES, W. B. 1925. Studies in the physical properties of Soils. III Observation on the electrical conductivity of soils. J. Agr. Sci. v. XV, Part 4.

10. McKORKLE, W. H. 1931. Bull. 426 Texas Agric. Exp. Sta. April.

QUICK DETERMINATION OF TOTAL PHOSPHORUS IN SOILS

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The common acceptable methods of gravimetric and volume determinations of total phosphorus in the soil involve a series of lengthy and laborious operations which constitute a determent in mass analyses.

The principal difficulty in using quicker colorimetric methods is the presence of large quantities of iron in soil extracts. According to existing methods of colorimetric determinations of phosphorus, iron must be eliminated by one or another method which involves great expenditures of time and labor.

For instance, according to Lebedyantsev's method, with subsequent colorimetry (3) iron is precipitated with iron potassium cyanide. The excess of the latter is combined with magnesium sulfate in a solution of definite acidity which is determined by titration with ammonia. The precipitated phosphates are again dissolved by means of sulfuric acid. Ferrocyanides of iron and of manganese are separated by filtering. The phosphorus in the filtrate is determined colorimetrically.

From the cited example it is seen that all the operations of removing the iron prolong the analysis.

We set ourselves the task of working out a simple method of colorimetric determination of total phosphorus without previously precipitating the iron even in soils which are rich in iron.

As a basis we used Kirasonov's method worked out for the determination of available phosphorus in the soil (2). We introduced a scale of light filters which eliminate the detrimental effects of iron. The soil was prepared for analysis by the method recommended by Gedroyts (1) which is ignition at low temperatures.

The procedure of analysis is as follows: A sample of soil 1-1/2 grams is put through a sieve with 0.25 mm openings. It is ignited in a porcelain crucible to a temperature of dark-red heat. It is then washed in a water bath first with a small quantity (3-4 ml) of concentrated nitric acid and then with diluted nitric acid. The extract thus obtained is passed through an ash-free filter and the residue is washed with dilute nitric acid and hot water.

To remove the nitric acid and the residue of silicic acid which interfere with further analysis we used double evaporation of the obtained solution with hydrochloric acid. The dry residue was dissolved in 0.2 N hydrochloric acid. The solution was transferred into a 100 ml volumetric flask and the same acid was added to bring the amount up to 100 ml.

The determination of total phosphorus in this extract is made by stirring 5 ml of the extract with a tin rod after ammonium molybdate is added. The extract is then compared with a standard scale prepared by Kirsanov's method. It should be pointed out that while the standard solutions have a clear blue color, the investigated solutions had a noticeable green shade. This is due to the presence of ferric iron, which under the conditions of our experiment is not fully restored. The difference in the shading is easily removed by colorimetring with the light filter scale which we propose. This scale consists of a series of test tubes (5-10) filled with a solution of iron chloride of various concentrations (See below for the preparation of the scale).

The comparison of standard solutions with the investigated ones is carried out in a 6 nest comparator. Back of the standard solution is placed a light filter test tube in the back of the investigated solution, a test tube with water. By properly choosing the test tube from the light filter scale it is possible to arrive at absolutely identical shades of color of the standard and of the investigated solutions. In the determination of total phosphorus the relationship between the sample and the dilution is different than in the determination of available phosphorus. Consequently Kirsanov's table cannot be used in computing the content of P_2O_5. It was therefore necessary to develop a formula for quick computation of the results of the analyses. The following formula met this requirement:

$$A - K \frac{ab}{1000\,c}$$

where: A — Content of P_2O_5 in %; a — amount of P_2O_5 in mg per 100 ml of the sample solution (see Table 1); b — dilution; c — the weight of samples in grams; K — conversion coefficient for absolutely dry soil.

With a dilution of 100 the formula takes the form of: $A = K \cdot \frac{a}{10c}$

Table 1

Values of "a"

	Test tube number containing the standard solution											
	1	2	3	4	5	6	7	8	9	10	11	12
Mg P_2O_5 in 100 ml of the standard solution	0,25	0,5	0,75	1,0	1,25	1,5	1,75	2,0	2,5	3,0	4,0	5,0

Note: Comma represents decimal point.

Preparation of the Standard Solution

Twleve consecutively numbered volumetric flasks are filled with the initial solution of dibasic calcium phosphate as indicated in Table 2 (0.2423 g chem. pure $CaHPO_4 \cdot 2H_2O$ in a liter of 0.2 N.HCl). The flasks are brought up to the 0.1 N.mark by adding a solution of hydrochloric acid.

Table 2

Preparation of the standard scale of solution of phosphates

	No. of 100 ml volumetric flasks											
	1	2	3	4	5	6	7	8	9	10	11	12
No. of mls of the added standard solution	2,5	5	7,5	10,0	12,5	15,0	17,5	20,0	25,0	30,0	40,0	50,0

Note: Comma represents decimal point.

From each of the flasks 5 ml of the solution are poured into test tubes numbered in the same way as the flasks. To this are added 5 ml of the solution of ammonium molybdate.

Preparation of the Solution of Ammonium Molybdate

Ten grams of ammonium molybdinate are dissolved in 100 ml of distilled water. 200 mm of hydrochloric acid (specific gravity 1.19) and 100 ml more of water are added. The resulting solution is diluted 5 times with water before it it used.

Preparation of the Scale of Light-Filters

A sample of 0.5-1.0 grams of dried iron chloride is dissolved in 100 ml of water. With a pipette, 1-2-3, etc. millimeters of solution are added into test tubes to which 2 millimeters of dilute hydrochloric acid is added to suppress the hydrolysis of $FeCl_3$. Water is then added to bring all the test tubes to the same volume (10 ml). The test tubes are tightly closed with stoppers and sealed with Mendeleev putty cement. In this form the scale can be preserved indefinitely. The original solution of iron chloride can be prepared also empirically so that intensity of the coloring of the soil extracts would not be beyond the limits of the scale.

The proposed method permits the use of Kiersanov's method in determining total phosphoric acid in soils with speed and accuracy within the accepted limits of colorimetry error.

In order to check the method, parallel determinations of P_2O_5 were made by the commonly accepted method (4). The results obtained with the proposed method and with Lorenz' method are shown in Table 3. The content of P_2O_5 is computed in percent of absolutely dry soil. The values are averages of 2 determinations.

The investigations were carried out in soils of the southern zone of the Khmel'nitskaya Oblast'. The method was checked for various dilutions. The results are shown in Table 4.

Although the dilution (as is seen in Table 4) does not play any special role it is more convenient to make the comparison in the middle range of the scale which with the given samples correspond to a dilution of 100.

Conclusions

1. A scale of light-filters permits the determination of P_2O_5 in the presence of considerable quantities of iron.

2. The method is suitable for mass determinations of total phosphorus even in a primitive laboratory.

In using this method a considerable economy of time is effected (up to 30% in comparison with the commonly used colorimetric methods of

Table 3

Comparison of methods of determination of total phosphorus in various soils

Soil	Depth, cm	P_2O_5 content, %		Deviations
		According to Lorenz	According to proposed method	
Chernozem calcareous	0—20	0,339	0,330	—0,009
Dark gray forest	0—20	0,118	0,120	+0,002
Gray forest	0—20	0,114	0,119	+0,005
Chernozem slightly podzolized	0—20	0,160	0,159	—0,001
Degraded chernozem	0—20	0,170	0,166	—0,004

Note: Comma represents decimal point.

Table 4

Effect of dilution on the results of determination of total phosphorus in the soil by the author's method (P_2O_5, %)

Soil sample No.	Dilution		
	100	200	300
1	0,330	0,330	0,284
2	0,123	0,120	0,121
3	0,120	0,119	0,112

Note: Comma represents decimal point.

determining total phosphorus).

Received November 16, 1959

BIBLIOGRAPHY

1. GEDROYTS, K. K. 1955. Chemical Analysis of Soils, Vol. 2, Selkhozgiz.
2. PETERBURGSKIY, A. V. 1954. Practicum (handbook) for Agricultural chemistry. Sel'khozgiz.
3. KHEYFETS, D. M. 1954. Methods of determining phosphorus in soils, in "Agronomicheskiye metody issledovaniya pochv" Akad. Nauk SSSR.
4. LORENZ, L. "Verst-st" Volume 55, p. 183.

A MODIFICATION OF TYURIN-KONONOVA'S METHOD OF DETERMINING READILY HYDROLYZABLE NITROGEN

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Requirements of plants for nitrogen are arrived at correctly by Tyurin's method of determining the readily hydrolyzable nitrogen in the soil. The need to make this method more accessible for outlying (peripheral) laboratories leads the Agronomic Laboratory of the Exhibitions of Attainments of the National Economy of the USSR to modify it.

In the Tyurin-Kononova method the distillation of ammonium after the hydrolysis of organic matter in the soil and the oxidation is carried out in a Kjeldahl apparatus, for which it is necessary to have a separate table and a water supply in the laboratory. The process of distillation requires constant watching.

With the modified method the quantitative determination of ammonium is carried out in "Convey" dishes. After filling the "Convey" dishes they are left without watching until the reaction is completed, i. e. for 6 or 8 hours or even until next day. If the data are required the same day then the dishes are placed in a thermostat for 2-3 hours at a temperature of 37°C. The "Convey" dishes are not large; they can be placed not only on a table but on a shelf. Each dish is a small glass container with 2 compartments formed by a glass ring fused into the center of the container. It is covered with a well-ground glass disk. The bent edges of the cup are also ground. To insure hermetic seal the ground surfaces are smeared with vaseline. The dimensions of the dish are as follows: Inside diameter, 7-8 cm; — Height 2-1/2 cm; — Volume, 25-30 ml. The diameter of the inner container is 3 cm, its height is 2 cm, and its volume is 6-8 ml.

Ammonia released by the addition of a 40% solution of NaOH to the analyzed solution in the outer compartment of the hermetically closed "Convey" cup diffuses into the inner compartment and neutralizes an equivalent quantity of a titrated solution of sulfuric acid. The latter is determined by difference between the quantity of sulfuric acid taken for the analyses and the acid that did not combine with ammonia.

Procedure: The hydrolysis of organic matter and the oxidation are carried out by the Tyurin-Kononova method. The content of the conical small flask is then transferred into a volumetric flask and the solution is brought up to the 100 ml mark by adding water. Ten ml of this solution are poured into the outer compartment of the Convey dish with a pipette. With a micro-burette 3 ml, of a 0.002 N solution of H_2SO_4 with an accurately determined titer are poured into the inner compartment; to this are added 3 drops of the Tashir[1] indicator. The dish is covered so that a small crack remains for the end of the pipette. Into the outer compartment 4 ml of the 40% solution of NaOH are quickly added with a pipette with a broken-off end. The cup is immediately closed and rotated for several seconds without lifting off the table. After 6-8 hours (or on the following day) the cover of the dish is carefully removed and the sulfuric acid not combined with ammonia is titrated directly in the inner compartment with a 0.002 N solution of NaOH with a micro-burette. The end point of titration is indicated by a sharp change in color in the indicator from lilac to red to a light green.

Concurrently with the determination of the hydrolyzable nitrogen a controlled determination is made. The determination must be preceded by a check on the hermetic closure of the cups with a standard solution of NH_4Cl prepared with a double crystallized salt.

Computation of the Results of Determination. The amount of readily hydrolyzable nitrogen (X) in mg per 100 g of soil is found in the following way:

$$X = (a - b) \cdot T \cdot 0.028 \cdot 100,$$

where: a is the number of ml of 0.002 N NaOH used in titrating the control sample; b — the number of mls of 0.002 N NaOH used in titrating the investigated sample, T — correction for the titer, 0.028 mg of N correspond to 1 ml 0.002 Normal H_2SO_4; 100 is the conversion coefficient for 100 g of soil.

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[1] The Tashir indicator is prepared in the following way: The basic solution — to 40 ml of a 0.1% alcohol solution of methylene-red are added 10 ml of 0.1% alcohol solution of methylene-blue. The working solution — to 1 volume of the basic solution are added 1 volume of alcohol and 2 volumes of water, after which the mixture is left standing for a while.

Table 1

Data of determination of readily hydrolyzable nitrogen in soil samples of the Smolensk, Vladimir, and Ryazan' Oblast's

Soil	Depth, cm	Amount of hydrolyzable nitrogen, mg per 100 g of soil by methods of	
		Tyurin-Kononova	Modified
Sod-moderately podzolized coarse clay loam	0—20	3,86	3,75
"	0—20	4,26	4,09
"	0—16	4,93	4,42
"	0—20	2,74	2,55
Sod-moderately-podzolized gley-like, sandy loam	0—20	2,74	2,86
Sod-strongly podzolized, sandy loam	0—20	4,37	4,45
"	0—20	3,30	3,19
Sod-podzolized gley-like medium clay loam	0—20	3,86	4,12
Humus-gley	0—20	5,77	5,77
Sod-strongly podzolized sandy	0—20	4,37	4,23
"	0—20	1,62	1,76
Sod-strongly podzolized coarse clay loam	0—20	1,90	2,10
Light-gray forest, strongly podzolized medium clay loam	0—20	1,62	1 96
	30—40	1,34	1 29
"	0—20	1,06	1.15
"	0—18	2,46	2,38
Deluvial-washed on medium clay loam	30—40	1,90	1,99
Gray forest, moderately podzolized medium clay loam	0—21	2,46	2,49
"	0—21	3,30	3,14
"	0—22	2,74	2,60
Light-gray forest, strongly podzolized medium clay loam	25—35	2,18	2,18
Chernozem leached, moderately thick, fine clay loam	0—15	2,46	2,21
"	0—15	3,30	3,42

Note: Comma represents decimal point.

In the event that 3 ml of 0.002 N H_2SO_4 is insufficient to combine with the ammonia liberated in the Conway dish, it is necessary to put a smaller volume of the investigated solution into the outer compartment or to work with higher concentrations of H_2SO_4 and of NaOH (such a case is possible when the quantity of hydrolyzed nitrogen is greater than 8 mg per 100 g of soil).

To compare the modified method with the Tyurin-Kononova method we made the determinations of readily hydrolyzable nitrogen in various soils (Table 1).

The data show that the differences in the results obtained from the 2 analyses do not exceed allowable limits. The simplicity and sufficient accuracy of determination of readily hydrolyzable nitrogen with this modified Tyurin-Kononova method permits its recommendation to laboratories. The described modification is of particular interest to 1 room laboratories not equipped with plumbing.

Received July 2, 1960

WORK OF COMMISSION V OF THE INTERNATIONAL SOCIETY OF SOIL SCIENCE AT THE SEVENTH INTERNATIONAL SOIL CONGRESS IN THE USA, 1960

E. V. LOBOVA

The work of Commission V was carried out in 8 major divisions:

I. Classification and geography of soils of major regions (including continents)[1] — 6 papers, including 2 papers from the USSR.

II. Classification and geography of soils of countries or provinces — 7 papers.

III. Principles and systems of classifications of soils — 8 papers including 1 paper from the USSR.

IV. Geomorphology and time as a genetic factor — 3 papers.

V. Genesis and classification of hydromorphic soils — 5 papers.

VI. Morphology and genesis of tropical soils — 9 papers.

VII. Morphology and genesis of soils of northern latitudes — 8 papers.

VIII. Conservation service and its application — 8 papers including 5 papers from the USSR.

The papers of the soil scientists of the USSR were published in special symposia which were presented at the Congress.[2] In addition a large part of them was published in summary.[3]

The problem of classification and geography of soils of continents, countries, and of provinces was the center of attention at the Seventh International Congress of Soil science.

The work of Commission V started with a series of papers on soil maps of continents. These maps were first, and in some cases second, and third, editions of existing maps in various countries and of systems and classifications. As decided at the previous Congress, similar cartographic work must serve as an approximation for the creation of comparable single type classification. Soil cartographic work made it possible to arrive at and to confirm a series of broad general geographic conclusions.

Thus, in Africa a considerable influence of ancient soil formation on the contemporary ones was revealed. There came to light complicated distribution of soil zones, disturbed both by the influence of soil-forming rock and by cold ocean currents (black soils of the Savanna in depressions where friable deposits of complicated composition were layed down. Dry tropics in the zones of moist tropical forrests). In South America a summary based on new factual material revealing new, previously unknown soils was prepared. These soils were described for the first time.

On the soil map of Asia[4] were found not only zonal patterns of soil distribution but also facies patterns. The grouping of soils of the tropical belt based on the hydrothermic regime of each group was worked out.

The soil map of Australia shows (like that of Africa) a connection between ancient soils and contemporary ones and reflects the important role of parent material.

The soil map of Eastern Europe was prepared in great detail. On it are differentiated provincial sub-groups of some soils. A system was worked out for showing the parent material. The soil map of Western Europe is a result of the fourth summary of cartographic work and shows the change in soils from north to south as a result of climate, relief, parent material, and vegetation. Below we give a short summary of the papers according to the 8 subdivisions:

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[1] Work on the preparation of continents according to published material was going on in the USSR before the Seventh Congress. Small scale maps were published for: Australia (M.A. Glazovskaya, 1945); Asia (Ye.V. Lobova, A.A. Yerokhina, B.F. Petrov, 1955); Africa (Z.Yu. Shokal'skaya, 1942); Europe (N.N. Rozov, 1957); South America (Z.Yu. Shokal'skaya, 1957, V.M. Fridland, 1957).

[2] Report of Soviet soil scientists to the Seventh International Congress in the United States. AN SSSR M. 1960. In addition, reports of pedologist of the Ukrainian SSR, of the Tadzhik SSR, and of the Latvian SSSR, were printed in special symposia. The symposia together with maps were exhibited in the USA.

[3] Seventh Congress of International Society of Soil Science, Madison, Wisconsin, 1960.

[4] Prepared at the Dokuchayev Institute, Academy of Sciences, USSR, with materials of Soviet and foreign pedologists under the direction of V.A. Kovda and Ye.V. Lobova, and an editorial board consisting of Ye.N. Ivanova, V.A. Kovda, Ye.V. Lobova, V.A. Nosin, A.N. Rozanov, N.N. Rozanov, and S.A. Shuvalov.

I. Classification and Geography of Soils of Major Regions

The soil map of Africa south of the Sahara on a scale of 1:5,000,000 Yu D'Oor. A summary of the legend is published on the map and contains the following basic sub-titles:

A. Coarse mineral soils

B. Weakly developed soils

C. Calcareous soils

I. Non-hydromorphic (Rendzina and brown calcareous soils).

II. Temporarily waterlogged calcareous soils.

a. Lithomorphic soils on dark clays in tropical and sub-tropical regions (on basic and calcareous rock).

b. Soils on dark clays in depressions (in tropical and sub-tropical regions).

D. Brown tropical soils of arid and semi-arid regions.

H. Brown tropical soils of humid regions.

I. Iron tropical soils (ferrisiallitic).

J. Ferrisol.

K. Ferrallitic soils.
  Halormorphic soils
  Hydromorphic soils
  Humus, non-hydromorphic soils (mountain)

In addition to this map there was also presented and published a map on a scale of 1:25,000,000. This map represents the "third approximation" or edition[5] The legend is based on the principle of genetic analyses of soil formation and is close to the classification of French Soil Scientists (in the opinion of D'Oor).

Of interest is the division of tropical soils of humid regions into 3 groups;

1. Ferrallitic soils (Latosol) in which there are few or almost no primary minerals. The clay part of the soil consists almost entirely of Kaolinite with an admixture of free iron oxides; often but not always gibbsite is present. The ratio SiO_2/R_2O_3 is <2. The degree of base saturation in horizons B and C is less than 40%

2. Ferrisol. The amount of unweathered minerals reaches 10% (in the fraction of 50-250 μ diameter). The exchange capacity is somewhat higher than in latosol. The degree of base saturation in horizons B and C is $<50\%$.

3. Ferrisiallitic (or ferruginous) soils. These soils contain considerable amounts of primary minerals. Along with kaolinitic clays there are hydro-microceous clays. Gibbsite does not occur. Exchange capacity is somewhat higher. Thus in moist tropical and equatorial regions of Africa there occur ferrolitic-lateritic soils under humid (rain) forests on various rock formations. Under the same conditions of dense humid forests, but on basic rocks, ferrisol soil is formed. Ferruginous soils are considered transitional. They develop under the relatively dry forests and under the grass savannas (Madagascar).

In the semi-arid and arid regions of Africa there are "brown tropical" soils, which are distinguished by a large content of non-weathered minerals, a considerable base saturation, and the formation of dense clay B horizon. Clay minerals in these soils are classified as montmorillonite and hydrous micas or illites. The latter are found in soils developed on basic rock.

Black tropical soils under savanna developed on montmorillonitic clays are considered to be lithomorphic with quite peculiar characteristics (swelling, cracking, stickiness).

The study of the soil map is somewhat difficult because the coloring is in one case according to type of soil (distinguished by color are hydromorphic black soils, and brown non-hydromorphic). In other cases the colors are according to the kind of parent material (ferrallitic soils on different rocks are indicated by contrasting colors). Such a method of coloring results from the primary importance not being attached to the bioclimatic principle, but to the effect of the rock. The sub-division according to rock is quite detailed.

Soil map of Latin America on a scale of 1: 25,000,000 by L. Bramao. On this map are shown the following soils: Association of red and yellow latosols. These include red yellow podzolic, red latosols (lateritic and ferrallitic) with concretions and others. These soils are formed in 8 countries of Latin America where the climate is moist and forests are widespread on sedimentary and crystalline rocks and on very different forms of relief. Fertility of the soils is from low to medium.

Dark red latosols include "terra rosa"[6] which are found in 5 countries of Latin America under forests. They are formed under conditions of humid sub-tropics and of humid tropical climates on limestone, tuffas volcanic, and crystalline formations on various forms of the relief. The fertility of the soil is from medium to high. Brown latosols in combination with tropical brown forest soils are prevalent in South America in the humid tropical climate on volcanic ash, limestone, and basalt on hilly as well as on mountain relief. The fertility of the soils is from medium to high.

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[5] The fourth edition will be published in 1961.

[6] Terra rosa is red soil of the type of "red clay".

Dark clay soils — regurs, rendzinas, talpetate, brunizem,[7] and chernozem are found in 6 countries of Latin America where the climate ranges from sub-tropical to temperate and with precipitation ranging from low to medium. The vegetation ranges from dry forest to steppe (Savanna-EL). Parent material — diabases, limestone, ancient alluvium on gently undulating and hilly areas.

Brown and reddish brown soils which include "terra-rosa," non-calcareous brown, brown forest, and chestnut soils are prevalent in 4 Latin American countries in the semi-arid Mediterranean moist temperate steppe climate under xerophilic forests and steppes on hilly areas.

Desert soils — red, grey, and sierozem are developed in 3 countries with tropical and sub-tropical arid climate on erupted volcanic and sedimentary rock under shrubs and kaatinga.[8] The relief ranges from level to hilly.

Trumao, including ando-hydrohumus latosols and rubrozem are encountered in 4 Latin American countries on sedimentary rock and volcanic ash. The climate ranges from moist sub-tropic to very moist. The vegetation is forests. The relief ranges from mountainous to hilly.

High mountain paramos soils include black andian, alpine meadow, gray forest, podzolic, and tundra soils. They are found in the Andes in the cool moist climate under forest and under low grasses on sedimentary and volcanic rock.

Other soils in Latin America include hydromorphic, lithosols, regosols, (friable skeleton type) and alluvial. One should note that the legend described here is more a legend for a regional map. This is apparent and was pointed out by the author who shows associations on the map.

Soil map of Australia on a scale of 1:5,000,000 was presented by the soil scientists Stephenson and Northscout in printed form. A paper on the geography of the soils of Australia was presented by S. J. Stephenson. For the soils of Australia a wide distribution of residual ancient soil is characteristic. The profile of these soils could not have been formed under present climatic conditions. Widely distributed are also salinized soils which are due to poor drainage of the continent. The soils are formed often on limestone and on basic rock.

Podzolic soils are prevalent in moist northern, eastern, and southwestern regions. Grey and brown soils of fine textures in the semi-arid regions are found. Black and red brown soils are found in the regions with seasonal excessive saturation. On coarse limestone material of the southern regions of Australia solonetzic brown soils are developed. The common desert soils are formed on clay loams, limestones, and on sands. They occupy large areas in the center of Australia.

Lateritic podzolic soils and red soils are encountered on quite different rocks and occupy large areas. They are heterogeneous in origin and are the result of previously existing more humid climatic conditions. The soils were formed apparently under the influence of more shallow ground water than exists at present.

Soil map of western Europe on a scale of 1:2,500,000 was reported on by R. Tavernie and E. Muckenhousen. The legend of this map was discussed in Ghent (1954), in Bonn (1957), and in Oxford (1959). The soils in the legends are divided into mountain and plain. Within the limits of each group zonal soils with lithosol and bog-soil sub-divisions are brought out. There are also distinguished valley soils, coastal soils, regosols, marshes, and soils on different parent rock.

For Central Europe the development of podzolic, grey-brown podzolic, brown forest soils, and of chernozem in the dry plains regions is characteristic. In the south and in central Europe in the mountainous regions soils ranging from brown-podzolic to Mediterranean and to rendzinas are formed. On the plains of southern Europe brown and red Mediterranean red-yellow podzolic soils, terra-rosa, chernozems, and chestnut soils are developed. In the extremely dry regions of Spain and Turkey sierozems are found. In the depressions of southern regions are formed black hydromorphic and black Mediterranean soils (smol'nitzi).

Soil map of Europe (eastern part).[9] The legend of the map was discussed at the International Conferences in Bucharest (1958), Moscow (1959), and in Budapest (1960). The legend contains some 130 sub-divisions of soils which are grouped in 3 genetic or geographical groups — soils of plains and of hilly territories, soils of mountainous regions, and complex soils. In addition to genetic groups, sub-groups and families and variations of soils shown in various colors and shades, the texture and parent material are indicated by black shadings and by symbols.

II. Classification and Geography of Soils of Countries or Provinces

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[7] Brunizems — humic soils with deep-lying carbonates.

[8] Kaatinga — thin dry forests.

[9] On a scale of 1:2,500,000 edited by I.V. Tyurin, Ye.N. Ivanova, and an editorial board consisting of: V. Kash, A. Musiyerovich, N. Nogina, N. Rozov, Ye. Rudnevaya, N. Stranskiy, V. Fridland, N. Chernesko, P. Shtefanovich, E. Eval'd. The map was prepared by the staff of the Dokuchayev Soil Institute, Academy of Sciences, USSR and by soil scientists of Albania, Bulgaria, Hungary, German Democratic Republic, Poland, Rumania, and Czechoslovakia.

In Part II most of the reports were devoted to sub-tropical and tropical regions of Africa, Peru, and Portugal. For Africa descriptions were given of: The southeastern parts (R. Hansen), Angola (Botelo and Azevedo), and the island of St. Thomas in the Gulf of Guinea. The soils of southwestern Africa are quite variable.

The part of Africa described by R. Hanson constitutes "parts of the world's belt of dry regions." Here rains occur during the warm part of the year, consequently there is considerable evaporation from the soil surface. In the northeastern part the precipitation is 400-600 mm per year. In the southwestern part it is 60-200 mm. There is almost no precipitation in the Namib Desert. All this creates conditions favorable to the formation of calcareous soils even on non-calcareous rock. The author describes three large groups of soils as follows:

1. Soils of dry forests (400-500 mm precipitation) with an organic content of 2%; pH equals 6-7; the A horizon is gray; the B horizon is reddish brown.

2. Semi-desert soils under a grass savanna (150-400 mm precipitation). They contain 1%-1-1/2% organic matter; pH is 7-8; A horizon is cinnamon-brown, sometimes grey; sub-soil horizons are compact. In them are formed carbonates, sometimes in appreciable quantities in the form of spots.

3. Desert soils under specific sparse vegetation (5-150 mm precipitation). Content of organic matter ranges from 0.2%-0.5%; pH value is 7-8.5. On the surface of the soil calcareous crusts are formed. In addition to the zonal soils there are formed in southwest Africa solonchak soils rich in sodium, secondary calcareous soils with crusts, grey calcareous soil with coarse texture, black, and dark grey fine clay soils. These soils contain 3% organic matter and sodium humates are found locally. The formation of brown soils of fine texture is noted in flat valleys with relatively low precipitation.

Hansen's report as well as those of others were accompanied by color slides which showed clearly reddening of the profiles of all the enumerated soils. Thus, soils called brown and chestnut are not like the corresponding soils in the USSR as they have a quite definite reddish tint in the profile, and as a rule are not solonetzic. Even the takyrs and the brown semi-desert soils have the pronounced red coloring. Even the sands of Kalahari are red. In this they sharply differ from the desert sands of the USSR.

The soils of Angola were shown on a soil map with a 1:3,000,000 scale. The territory of Angola which lies between 4 and 8 degrees southern latitude is distinguished by quite variable soils. The authors of the report describe in detail the soils both with respect to bioclimatic conditions and to parent material. They set up the following major soil groups:

1. Grey and brown soils under semi-arid dry forests and shrubs, saturated, calcareous with a compact B horizon on "siallitic" clays. Similar but non-calcareous soils are called para-sierozems.

2. Reddish or brown Mediterranean soils developed under open mesophyllic forests with annual precipitation reaching 500-700 mm. These soils contain 2% organic matter, their B horizon is distinguished by a varying degree of compaction. The C/N ratio reaches 13-16. Soils of similar type but more leached are called brown-reddish. They are non-calcareous. The reaction in the upper part of the profile is neutral and in the lower it is acid.

3. Tropical ferrisiallitic soils are distinguished by relatively high content of minerals. Their clay fraction is composed mainly of kaolinite and hydroxides with different admixtures of micaceous clays. Exchange capacity and the amount of non-weathered minerals are usually higher than under ferrallitic soils. These soils could be considered of the same type as red loams (V. Kubiyena).

4. Ferrallitic soils are poor in mineral contents. The SiO_2/Al_2O_3 ratio is less than 1.7. The clay fraction consists largely of kaolinite and hydroxides (gibbsite occurs often but not always). In these soils there is observed a less stable texture than in ferrisiallitic soils. There are also formed concretions and lateritic crusts, the latter often occurs in soil profiles but does not constitute a distinguishing characteristic. On the map are shown the distribution of lateritic crusts at the depth of less than 1 meter. It was found that ferrallitic soils do not form cracks during dry periods.

In addition to the zonal soils the authors showed on the map and defined hydromorphic sandy, primitive, and also black tropical soils under the name of "barros" which are distinguished by stickiness, cracks, and by the presence of montmorillonitic clay.

An analogous classification was employed by S. García and J. C. Cardoza for the soils of St. Thomas and of Prince Islands, and by A. J. S. Teixeira for the soils of Portuguese Guinea. The most widely distributed soils of Guinea are ferrallitic, ferrisiallitic, regosol, and hydromorphic. They are characterized by their chemical analysis which was supplemented with some material on physical properties. It appears that if the ferrallitic soils are placed in the following order: red, light orange, brown, light brown, then the quantity of bound water in the soil increases from the red to the light brown.

Soils of South Portugal (J. C. Cardoza) were investigated by using the concepts of "series" and "phases." The concept of great soil groups was utilized in the preparation of the soil map on a scale of 1:250,000. On this map are shown brown soils (calcareous and non-calcareous), Mediterranean,[10] red yellow, red yellow podzolic, grey, and grey-brown podzolic. Besides the zonal soils there should be mentioned also the lithosol, hydromorphic (planosol),[11] and "barros." The latter are close to the black tropical soils but are distinguished from them by a lighter coloring and the absence of granular structure in the organic horizon.

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[10] As to profile they resemble the red earths of the USSR.

Podzolic soils of Southern Portugal are developed under oaks (Quercus super) with pinion or under deciduous broadleafed forests. They are distinguished by a thick A horizon (up to 1 meter) and belong in the group of grey and brown podzolic soils. They are often considered as relic soils.

The soils of Peru (M. Drozov and others) are described schematically with designation of the following groups:

1. Arid littoral soils

2. High mountain organic, acid soils of the Andes

3. Soils of the eastern slopes of the Andes

a. red and yellow lateritic under forests

b. brown shallow soils of sub-humid forests (with carbonates on the plains)

4. Lateritic soils of the Amazon valley on tertiary and lagoonal young eluvial rocks.

At the present time (according to J. S. Cardoza) there arises the problem of separating the tropical podzols from the northern.

In the series of papers on the geography of soils (sub-division II) a communication was presented on a soil map of the Federal German Republic on a scale of 1:1,000,000 (V. Goldschtein). On this map are shown 45 subdivisions with the designations of soil group, soil genus (texture), and of parent material. For instance, brown soils are shown on sandy clay on basic or medium crystaline rock, and of the "ranker"[12] type. The author calls attention to the fact that "Parabraunerde" are synonymous to soils of the "lessive" and "grey-brown podzolic" group. However, the genesis of the B horizon in these soils of Western Germany is unique. This horizon which was studied by geologists is formed on one moraine as a result of clay deposition.

III. Principles and System of Classifications of Soils

In this sub-division there were 2 large papers — by G. Smith,[13] and by Ye. N. Svanova and N. I. Rozov.[14] Both papers were published. In addition, 2 reports were devoted to the problem of nomenclature, the designation of soil horizons (E. Whiteside), and to the concept "Pedon" in the American classification system R. Simonson and D. Gardner). The papers of Del'Llano and Sees dealt with the classification of tropical soils. Kh. Mal'ter's paper outlined the principles of classification of friable soils according to their textural composition.

IV. Geomorphology and Time as a Genetic Factor

In this sub-division there were presented 3 reports on the subject of relation of soil formation to relief and 1 paper of a more general character (G. Men'en).

Investigations in Brazil (Minas Gerais) permitted the author to relate types of soil formation to elevation and to age (M. N. Kamargo). Thus in young mountainous regions are formed mountainous young and rocky soils (lithosols); a little lower — brown acid soils and humic podzols. On the plateau and on the gently undulating heights ("shapadas") there develops "in situ" friable, highly weathered, and leached lateritic soils. On the younger plateaus are the less mature, shallow lateritic soils. Locally there were formed soils which are transitional to the red-yellow podzolic.

Investigations in Kenya (J. Thorpe and E. Bellis) show that this high country in eastern Africa represents a remnant of a peneplain of different ages: early cretaceous, early middle miocene, plio-pleistocene. In addition there are often outcrops of ancient sedimentary rock. The presence of rocks of various ages makes the appearance of soils of various ages and stages of development possible. On the most ancient and well-drained levels where the annual precipitation is appreciable (2,500 mm), deeply weathered mature lateritic soils are formed. On the gently undulating lower-lying pleistocene levels and under conditions of two-season sub-humic climate (dry-moist) are formed the black tropical or "black cotton soils" (grumosols).

In the semi-arid climate of the tropical belt are formed chestnut and brown soils on pleistocenes and on younger rocks, sometimes together, with solonetzic and solod soils. Soils in high mountainous cold regions are rich in humus. Above the timber line lie the peat soils.

In the paper by Rue, Milne's concept of the Catena was outlined. It is supplemented by the views of Pallister, of Bushnell, and by the new investigations of the author.

R. Men'en's paper was a broad generalization of the problem of the effect of ancient soil processes on contemporary processes in western tropical Africa. The study of the soils of Africa shows that profiles of tropical soils exhibit characteristics of ancient pre-quaternary processes and also of subsequent changes in the moisture regime and in the evolution of relief. R. Men'en emphasized the following conclusions:

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[11] With a compacted horizon in the middle part of the profile.

[12] A weakly developed soil on non-calcareous siliceous rock.

[13] Guy D. Smith — Soil Classification, 7th Approximation, U.S. Department of Agriculture. 1960.

[14] Classification of the Soils of the USSR. Reports of Soviet Soil scientists to the Seventh International Congress in the USA in 1960.

1. It is known that many lateritic crusts remain from the tertiary period in Senegal, Sudan, and Upper Volta. It is also established that in semi-arid countries (Mauretania, Nigeria) there are on the surface of the soil sprinklings of iron concretions which were formed during more humid periods in horizons of tropical leached soils. These "ancient" concretions appeared on the surface as a result of soil erosion.

2. Under conditions of the contemporary relatively dry climate (1,200, mm) there have taken place processes of ferrallitization. Such a paradoxical phenomenon has been established on schists weathered under the protection of thick iron crusts (where apparently special hydrothermal conditions are created-E. L.).

3. The effect of ancient soil formation on the contemporary is often due to the ancient products of weathering being brought into contemporary soils. Thus in the region of the Upper Volta weakly leached tropical soils are strongly enriched with iron crusts, although the process of laterization is weakly developed in these soils. These crusts are formed from the iron which was brought from outside as a result of its mobilization from tertiary crusts. In many cases contemporary conditions of soil formation do not appear to encourage the process of deposition of iron crusts, yet it does take place. In such cases, it is necessary to determine accurately the contemporary soil climate.

4. One should not confuse the intensity of soil formation with the time of soil formation. Thick crusts of weathering often form as a result of lengthy processes and not as a result of their intensities. In these cases the age of the crusts can be established safer on the basis of the analysis of the forms of relief and of their evolution.

V. Genesis and Classification of Hydromorphic Soils

In this division 2 reports were devoted to peat and peat-like soils and 3 to gley and bog soils.

1. Soil formation in the soils rich in organic matter. B. Van Heyvel'n, A. Engerius, and L. Yu. Pons). In peat, when conditions of drainage are changed the following soil forming processes take place:

a. Physical ripening which consists of dehydration of the mass of the peat. The quantity of peat is decreased. The water-holding capacity is increased. The environment becomes suitable for plants. With lengthy ripening organic matter is formed.

b. Decomposition, which takes place in aerobic environment with the participation of microorganisms. This leads to an increase in nitrogen content.

c. Decay Vererdung. Depending on environmental conditions one finds eutropic and oligotrophic decay. The decayed horizon has the lowest C/N ratio and the highest content of mineral substances and is called A_1 (subtypes are: mull-like and moder-like) similarly Muck, Moorerde, Vererdete Moor.

d. Leaching and accumulation. Sometimes as a result of decay there are formed unstable forms of humus. This is aided by low values of pH, absence of iron or aluminum, high level of ground water, and plowing. The time of accumulation of humus in peat areas was determined ratiometrically (with C-14). The coagulating agent appears to be iron. It takes 500 years for a sphagnum bog to attain a thickness of 20 cm.

2. Genesis and Classification of reclaimed peat soils in connection with primitive soil formation (L. Yu. Pons). When bogs are reclaimed there takes place primary soil formation which is manifested in "physical, chemical, and biological ripening." With lengthy "physical ripening". With lengthy "physical ripening" the soil irreversibly dries out and under more favorable conditions there begins an intensive soil formation. An organic horizon A_1 is formed with stable forms of humus (Mull and Moder).

The classification scheme of peat soils is founded on these processes. Further division depends on the presence of an A_1 horizon. The smaller units are designated in accordance with the character of the A_1 horizon, the presence of a B horizon, and according to physical ripening.

Reclamation of peat soils after drainage leads to the appearance in them of new processes, and to the formation of new horizons. These processes are described in a paper of Yu. Schelling:

1. Usually after drainage there is an irreversible physical dehydration of the peat in hydromorphic soils.

2. In hydromorphic soils after completion of drainage there can be recognized 2 gley horizons; an upper one-residual, old, and a lower contemporary one.

3. The utilization of drained soils as pastures or crop land leads to the formation of an organic A horizon.

4. Later with vertical movement of soil water, a B horizon is formed. These observations can serve as a basis for classification of reclaimed soils.

In the 2 papers of J. Reuter and G. E. Shtremme were shown some processes on gley soils underlain by stony clay loam. The formation of gley or pseudo gley soils was described in Germany on various rock formations soils of the "lessive" type. Usually gley soils are acid, unsaturated oligotropic. A different picture was observed by the writer in soils of stony calcareous clay loam of Würm age. In spite of their slow formation in a humid climate they are rich in bases (eutrophic). In these soils was observed recent "browning" along with the formation of stangogley.

In Shtremme's report data are given on the fluctuation of ground water in soils on stony clay loam. These soils are gleyelized stony clay loams underlain with the more clay basic moraine. Observations of wells showed that the level of ground water fluctuates from 1-3 meters, and depends not only on the climate but also on the utilization of the wells.

VI. Morphology and Genesis of Tropical Soils

The study of the process of ferrallitization on calcareous basic granites was carried out on a wide scope and permitted Ray Ober and N. Lenneff to determine the ages of certain soils.

The authors utilized the following analysis: 1. Chemical composition of calcareous basic granites, 2. Annual volume of drainage water which filtered through the soil (according to Hennen), 3. Contents of Si, Ca, Mg, K and Na in the drainage water. Drainage water was collected at 3 points which corresponded to the basic stages of weathering of the granite. Namely:

a. At a bleached granite on a clay of montmorillonitic stage.

b. At a bleached granite at a gibbsite-kaolinite stage (clay).

c. Below a thick layer of multicolor clay. With precipitation reaching 2000 mm per year one can assume that it would take from 22,000 to 77,000 years to weather 1 meter of granite. With precipitation of 1,500 mm, 53,000 to 102,000 years would be required. It should be kept in mind that silica of silicates is never fully liberated by ferrallitic weathering because from one-third to one-half of it is utilized in forming kaolinite.

The question of formation of podzolic soils in the tropics was treated in 2 papers.

The report of Raimondo Costadelemos showed new data on the soils of Sao Paulo in Brazil. These soils called "Marilia" are developed on a calcareous sandstone under dry partly deciduous tropical forests. The amount of annual precipitation fluctuates from 1000 to 1300 mm. The dry season lasts from April to October. Absolute elevations reach 300-700 meters. The crops of the region include coffee, cotton, and coconuts. The author compares these soils with the red-yellow podzolic soils and points out that morphologically (with respect to development of the A_2 horizon) they are close, but the "Marilia" soils have a much greater base saturation. According to the base saturation characteristics, these soils could be closer to the red-yellow Mediterranean soils but in the latter the formation of a podzolic horizon is not observed. Therefore, the existence of a podzolic process is doubted by the authors.

Quite special soils were studied by Yu. Rik'ye in Madagascar at an elevation of 1200-2000 meters with annual precipitation from 2000 to 4000 mm and a mean annual temperature ranging from 10-15°C. The vegetation consists of acacia, mosses, and ferns. The soils were developed on basalt, basaltic ash, and trachyte. The profile of the soils is morphologically podzolic but it turned out that the A_2 horizon is composed of phytolites of different forms which exist in local grains, ferns, and acacias. The author concludes that the soil, which according to morphological indices was called podzolic, is in reality not such because the formation of the A_2 horizon takes place as a consequence of biogenic accumulation of SiO_2. It seems to us that Rik'ye's investigation could have a wider not only local "exotic" meaning. In tropical soils with strong ferrallitization (laterization) plants have wide possibilities for absorption of Si which later through plant residues forms an accumulation of biogenic character in the upper parts of the profile. Undoubtedly, under conditions of a moist tropical climate, weathering goes deeper than in the case of podzol formation with the liberation of the large amount of silica which can create a psuedo-podzolic horizon in a biogenic way.[15]

In the light of the investigations reported by Rik'ye it would be well to examine the common concepts of podzol formation in the tropics.

The papers by S. Simonett, Yu. Bennem, L. Vettori, and Kh. Obeng (partly) were devoted to the characteristics of the chemical mineral composition of tropical soils. In Australia, soils were studied on basalt with different moisture conditions (S. Simonett). With 870 mm of precipitations there are formed black tropical soils together with laterites low in humus. With 2400 mm — red soils or humic latosols. It was established that there is more gibbsite in upper parts of the profile and that the amount of kaolinite increases with depth. Comparison of various soils at a depth of 25 cm showed that with the increase of precipitation the content of kaolinite and goethite is reduced, and that of gibbsite, hematite, and magnetite is increased. Observations in Brazil (U. Bennem) showed the different character of the B horizon and the effect of sesquioxides and of the character of the clay faction on its pH.

A. V. Moore reported important conclusions on the effect of annual burning of grasses on soil fertility in the Savanna of western Nigeria. It turns out that burning is useful if properly carried out. Burning must be done quickly. Slow burning leads to a reduction in the quantity of humus, nitrogen, and of exchangeable cations.

The report of R. Diudal and M. Sepraptokhadjo was devoted to andosols (black soils on basalts) in Java.

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[15] The biogenic character of light horizons in solods was pointed out by I.V. Tyurin (1937); in grey forest soils of Tibet by S.V. Zonn (1959); and in dark colored meadow soils by A.A. Rode, Ye.A. Yarilova, and I.M. Rashevskaya (1960).

are formed in conformity with the relief (Catena) together with lateritic soils. Andosol develops on hills. On the slopes subsequently develop (from top to bottom) brown latosols, reddish brown, and red latosols. In Japan the andosols are formed in conjunction with podzol soils, while in Nicaragua with grumosols. The andosols in Java are reddish and their organic horizon is dark. They smear when rubbed. The SiO_2/R_2O_3 ratio is low. Their reaction ranges from weakly acid to neutral. With time, the andosol here is transformed into latosol.

It follows from the paper that dark soils on basalt acquire zonal characteristics in the process of development. Thus in Java they form lateritic soils, in Japan, possibly podzolic.

The catena method of studying soils, i. e., along the profile: watershed→divide→slope→lowland, is widely employed abroad. The grouping of soils according to catenas corresponds partly to the classification of I. P. Gerasimov, Ye. Ivanova, and A. A. Zavalishina (1937). According to this method soils are divided into automorphic, xeromorphic, and hydromorphic.

Saline and basic soils in the Indus-Ganges plains were described in a report by S. P. Raichoudri and R. S. Murchi. The authors stress that soils are salinized (solonchaks solonetz, solods) as a consequence of poor drainage, hot climate, and high evaporation.

VII. Morphology and Genesis of Soils of Northern Latitudes

In this division, soils of northern latitudes were considered both from the standpoint of genesis and with a view to presenting some general problems of soil geography.

The prevailing texture of Alaska soils is clay loam although sandy and clay soils are found. In some regions there are noted calcareous parent materials (possibly also loess). Tundra soils are usually acid with a base saturation less than 50%. Most of the minerals are allogenetic and the translocation of clay along the profiles was not established.

The horizon at a depth of 25-50 cm is considered a relic which remained from a more warm climate. With C-14 it was established that the age of this fossil organic horizon is 8-10,000 years. For the tundra soils of Alaska the translocation of layers as a result of freezing processes is characteristic. The authors refer to the work of Liverovskiy, Kreyela, Gorodkov, Svatkov, and of others.

Podzol soils were discussed in 2 papers. In one of the papers by F. Konink and Lariusell a morphologic description was given of iron, organic iron organic-podzolic soils in sandy regions of the Antwerp province.

The paper by K. Kavaguchi and Yu. Matsuo was devoted to results of experiments and study of mobility of iron in A_2 and B horizons of podzolic soils. The basic conclusions presented in this report are as follows: 1. When the quantity of mobilized agents (protective colloids, chelates) is greater than iron oxides then the latter are removed. This process corresponds to the removal mechanism in A_2 horizon. 2. An opposite relationship corresponds to the mechanism of the formation of the B horizon in podzolic soils.

J. Pelichek presented a classification of Central European podzolic soils. In the region of central Europe in Czechoslovakia 3 soil groups — podzolic, brown forest, and grey forest soils are widespread. Each group is sub-divided into genetic types. The basis of this sub-division is the character of the vertical movement of sesquioxides and of SiO_2. In grey and in brown central-European soils there is no vertical movement of Fe_2O_3 and of SiO_2 but in the podzolic soils it exists. In some podzols called kaolinitic there is also a translocation of Al_2O_3 and of SiO_2. The author proposes to call podzolic soils orthopodzolic and soils of the "lessive" type parapodzolic.

In a paper by S. Pavlink are outlined new data on grey forest soils of Canada (Alberta and the Meer River). In forest regions of the country grey forest soils were developed as a result of the establishment of forests on the moraines in the post-glacial period.

The formation of grey forest soils in the park (forest-steppe) part of the country took place (according to S. Pavlink) as a result of the invasion of Populus tremuloides into formerly developed chernozems. Thus the evolution of the soils in the northern part of Alberta proceeds according to the scheme chernozem→degraded-chernozem→gray forest soils.

Complex paleographic problems were elucidated in a paper by E. Shonkhal's. The method of dating humus horizons with C-14 permitted the authors to designate the forest soils investigated by them as holocenic (10,000 years). In these soils were established a translocation of Fe_2O_3 and of SiO_2; this indicates colder climatic conditions of that period. Soils developed on loess-like formations called "lessive" (because there is no translocation of Fe_2O_3) begin forming during the late Würm time.

In a report by L. Sziuch are given data on the division of the chernozems of Central Europe into 2 types, the central European and the Danube type. Central European chernozems are usually leached, degraded, and developed on oligocenic and sarmatic loess-like strata and are distinguished by a red color. The Danube chernozems are calcareous at a depth of 30-40 cm. The precipitation of the carbonates have the form of micellium. These chernozems developed on valley loess have a light yellow sub-soil.

VIII. Conservation Service and its Application

In this division papers of soil scientists of the USSR predominated. They were devoted to: large scale mapping (P. Vlasyuk); the evaluation of soil of Kazakhstan (Uspanov); and in the Kuban' Delta (Ye. S. Blazhniy); and to soil improvement (N. Blagovidov). Foreign soil science was represented in this division by papers of A. Aandal', A. Vink, and Yu. Desonett.

In Aandal's paper were discussed the general principles on which work on improvement and reclamation of soils should be based. In A. Vink's paper were elucidated principles of the work of the Soil Survey in Holland. Soils are studied from various points of view in order to establish precisely the practical value of each separate type. The suitability of soils (in addition to the economic parameter) is determined on the basis of crop yields, cost of production, risk of production, and character of the soil.

Yu. Desonett suggested a binary classification of soils based on their agronomic value. This classification is founded on 2 basic properties of soils: The thickness of the plow layer and the water holding capacity of the soil.

Conclusions

The outlined material on the works of Commission V in Madison, Wisconsin (1960) made possible a brief review of newly solved and of indicated problems in the field of genesis and geography of soils. It seems to us that at the present time it is well to focus attention on the following:

1. Podzolic soils of the tropics and subtropics are not sufficiently investigated although in their study there arose a number of complicated problems which have general significance. Thus in Portugal are described "whitening of soils" which resemble podzols, but the fact that these soils are found under broadleaf forests and that they have a thick organic horizon forces us to doubt their podzolic nature. In the estuary of the Amazon there are many podzol soils of various thicknesses. According to Cardozo they should not be compared with podzolic soils of the Borealic latitudes. The same problem arises with the soils of New Zealand.[16]

The possibility of the formation of a light silica horizon in tropical soils by way of biogenic accumulation shown in Rik'ye's paper could point to the specifics of the so-called "podzol formation in the tropics" and could serve as a basis for further study of this problem.

2. A complicated nomenclature exists for various brown forest soils. However, it is possible to show some correlation in this nomenclature. Soils of sub-tropics in southern Europe are called "brown-southern." They can be considered analogous "cinnamon-brown soils." Within the limits of dry zones of the tropical belt are described brown soils. They are all distinguished by siallitic character of weathering and also (which could be seen in the slides) by considerable reddening of the entire profile. According to D'Oor, south of the Sahara Desert (with 100 mm of precipitation) there is a belt of red-brown desert soils under thorny-shrub vegetation. These soils are calcareous and belong in the arid zone.

Brown soils of semi-arid zones of the tropical belt (500-700 mm precipitation, 20-24°C annual temperature) are described in an explanatory note appended to the soil map of Angola (it was shown at the map exhibit). These soils are formed under open Xerophytic forests and shrubs. They contain 1.5% organic matter and are distinguished by a compacted B horizon. In these soils there are established elements of solonetzization and of salinization. They are compared with brown soils of semi-deserts and with sierozems. With greater leaching (700 mm) similar soils are non-calcareous. It is proposed that they be called para-sierozems.

Reddish-brown soils of semi-arid zones are developed under conditions of higher moisture under shrub savanna in tropical xerophytic forests. It is suggested (K. Cardozo and others) that they should be considered analogous to the red Mediterranean soils. Tropical and sub-tropical soils, transitional to laterites, are now called ferrisiallitic (some soil scientists identify them with red clay soils (Red loams according to V. Kubiyen). The establishment of a transitional ferrisiallitic type of soil in the tropics is from our standpoint, quite important because a connection will be thereby established between the siallitic and ferrallitic (lateritic according to the old terminology) soil formations. It will also enable a differentiation in space of the 3 world belts of soil formation: the temperate — siallitic; the equatorial, and the tropical — ferrallitic. The establishment of the transitional type is sufficiently justified by its chemical and genetical characteristics.

3. Black tropical soils have up to now been the subject of wide study. They are developed in dry parts of the tropical and sub-tropical belts under savanna or under forested savanna where 400-800 mm of precipitation fall per year. Dark soils contain 1.5%-2% humus. They are cloddy, they crack and are sticky. Many properties of these soils are due to the formation in them of montmorillonite clays. In the opinion of foreign soil scientists the black soils are lithogens. Black tropical and sub-tropical soils are described in Portugal (barros); in South America (regurs, tal'petates); in India (regurs); in Africa (Angola barros, Ghanaian gil'gais, grumosols in Tanganyika and in Kenya); in Indonesia (Margalitic); in the United States (grumosols). In R. Diudal's paper it was stressed that the occurrence of black soils was established also in Europe; in Bulgaria, Yugoslavia, and Spain. It seems to us that black sub-tropical should be combined with black tropical ones. According to Johnson the "grumosol" soil of Arizona contains less montmorillonite than do the black tropical soils. In the same soil there are formed allophane, and the content of mica and kaolinite is low. Johnson established forms of combinations of humus with clay minerals.

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[16] It should be pointed out that in a paper by Adzhara (1933), B.B. Polynov emphasized the need to study the differences between podzolic soils of the subtropics and of the temperate belt.

4. For tropical soils there is at the present time a sufficiently well worked out classification system which is based on the development of the process of laterization or ferrallitization (Fe, Al), from young soils under lithophylic lichen to a mature soil (Ober, Lenef, D'Oor). The interaction between zonal and lithomorphic processes is not always clearly indicated in these classifications.

5. The age of soils and also of various horizons has been widely studied by geomorphological analyses of the landscape (Men'en) and also by direct determination with the radiometric method (with C-14) (Tedrow, Douglas, Shonkhal's).

6. Notice should be taken of the broad studies of clay materials and of various types of soils. Ferrallitic soils are identified by a constant presence of gibbsite. Ferrisol, i. e., weakly laterolized soil is recognized by the prevalence of kaolinite and the absence of gibbsite. Montmorillonite indicates black tropical soils. Soils of the Mediterranean climate are recognized by the illite content (studies of Kh. Al'bared and others).

One could apparently express the opinion that the composition of the clay minerals makes it possible to determine differences in soil formations within broad bioclimatic belts but not within zones. The latter can be characterized additionally by the combinations and quantities of the minerals.

7. From the papers and the excursions we were able to become acquainted with the following soil processes which were new to us.

(1). Clay formation under conditions of moist sub-tropics;[17] on non-calcareous non-saline material. Under these conditions there is formed a viscous compacted B horizon in soils of dry steppes and of deserts under specific steppe and cactus vegetation.

(2). The forming of "hardpan" — an extremely tight cemented horizon which takes place as a result of the liberation of mobile iron and of silica under conditions of high temperature and strong spring wetting. During the dry time of the year there occurs an irreversible cementation. In soils with hardpan vermiculite is formed also.

In summarizing the work of Commission V one could make the following general conclusions. Considerable strides were made in the fields of geography and cartography of soils, and in the problem of regionalization (subdivisions I and VIII). Lively exchange of views was had and substantial reports were presented on classification of soils (sub-division III). More and more the relation of the process of clay formation to zonal bioclimatic conditions is being discovered (sub-divisions V and VI). There are a number of attainments in the field of paleopedology which became possible owing to wide application of the radiometric method (C-14) in the determination of the age of organic horizons. Successful work on genetic classifications of soils of the tropical and equatorial belts are continuing (sub-division VI). Several studies were presented on such soil-forming factors as time and geomorphology (sub-division IV).

Among the complex and by far incompletely solved problems are: the investigations of cultivated soils, application of soil classifications in the evaluation of soils, establishing nomenclatures for soil horizons, and the determination of the place of many soils in the world classification system. The solution of these problems can be arrived at by the preparation and the publication of maps as well as by the continuation of work on the classification, geneses, and regionalization of soils and on preparation of monographs on soil groups and on major regional groups.

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[17] Clay formation under conditions of dry subtropics on a calcareous material were described in the USSR for the brown soils (I.P. Gerasimov and for sierozems A.N. Rozanov).

CHRONICLE

SIXTIETH BIRTHDAY OF V. M. KLECHKOVSKIY

The end of 1960 marked 60 years from the date of birth, and 45 years of scientific-pedagogical, and civic activity of Academician of VASKhNIL (the Lenin All-Union Academy of Agricultural Sciences), corresponding member of the Academy of Agricultural Scientists of the German Democratic Republic, Doctor of Chemical Sciences, Professor Vsevolod Mavrikiyevich Klechkovskiy.

For thirty-five years the scientific and pedagogical activity of V. M. Klechkovskiy took place in the Timiryazev Moscow Agricultural Academy. While still a student Klechkovskiy showed ability as an investigator and was noticed by D. N. Pryanishnikov who invited him to aserve as assistant for the Chair of Agricultural Chemistry at the Academy when he completed his studies.

Klechkovskiy is the author of 200 publications in the fields of agricultural chemistry and biophysics and also on some questions of chemistry and physics. He is the author and co-author of a number of texts and manuals in agricultural chemistry used for Agricultural Universities and Technicums. His many-sided knowledge and broad scholarship made it possible for Klechkovskiy to solve successfully problems in Agricultural Science by utilizing the attainments of physics and chemistry.

During the pre-war period Klechkovskiy's investigations dealt largely with problems of agricultural chemistry. His first years of work in the Chair of Agricultural Chemistry were devoted to continuation of investigations, which began with his thesis on the quantitative laws of the effects of fertilizer. He published a number of papers in this period in which he gave the experimental and theoretical solution of problems and changes in fertilizer efficiency. During a 10-year period foreign literature contained many conflicting views on this (at that time) controversial question.

In the field of agricultural chemistry Klechkovskiy worked out the question on the value of physical-chemical properties and of the mineralogical composition of soils and of their interaction with fertilizer. The role of biological peculiarities of various agricultural plants in the assimilation of phosphorus from its adsorbed state in the soil was determined. This work was an important contribution to the understanding of complex interrelationships between the soil, the plant, and fertilizer which determine the effectiveness of fertilizer.

During the same period V. M. Klechkovskiy carried out a series of experimental and theoretical studies relating to the question of plant nutrition and to the application of fertilizer to various agricultural crops. These broad investigations in agricultural chemistry were generalized by Klechkovskiy and were included in the classical work "Agrokhimiyu" by D. N. Pryanishnikov in the form of a separate chapter under the heading "Systems of Application of Fertilizer in Specialized Crop Rotations" which was published in 1940. The ideas on systems of fertilizer application in specialized crop rotations expressed in this chapter have not even now lost their scientific and practical importance.

After the Great War of the Fatherland the scope of Klechkovskiy's theoretical and experimental investigations was greatly broadened. He was one of the first in our country to recognize the timeliness and the wide applicability of the methods of atomic tracers in agricultural science, and was the first (in 1946) to use this method in agricultural chemical investigations.

The use of tracers in agricultural chemical investigations opened new possibilities for deeper experimental study of processes of nutrition and of ionic exchange in plants—thus deepening and widening our knowledge of the nature of these processes. The application of the method of tracers also permitted a quicker and more reliable method of studying the movement of substances in soils.

The adsorption and exchange of ions and other processes takes place with the application of fertilizer into soils. Many of the important problems in agricultural chemistry could not be studied and could not be properly solved without the application of isotope methods.

In 1947 V. M. Klechkovskiy once again became the head of the Biophysical Laboratory of the Academy. Being one of the first of its type in our country the laboratory became the Methodological Center and served as the originator of wide application of Atomic Techniques and practices for agricultural, scientific institutions and for schools.

The staff of the laboratory carried out broad investigations in the field of plant nutrition,—the use of fertilizer, and also in the field of radioactive products of division in agriculture. The results from these studies have great theoretical and practical value. These investigations became an important contribution to science and the laboratory was rewarded by high praise from the government.

The great theoretical and practical importance of the agricultural chemical aspects of the problem of radioactive fall-out is due to their occurrence in nature. The danger of wide dissemination of such substances as strontium-90 and cesium-137 and their entry into the biological circulation is created primarily by atomic weapons tests. The soil-plants link is the principal means of introducing fall-out into the biologic circulation. It is important to determine the laws governing the behavior of these substances in soils and in plants, and to understand the conditions which could reduce or on the contrary increase fall-out in plants.

In order to find out the value of various products of fall-out as contaminants of agricultural objects it was necessary to organize a study of their behavior, their interaction with soils, and of their entry into plants.

The Laboratory headed by Klechkovskiy undertook the solution of these important problems in the Soviet Union. In a short period a large volume of scientific works was completed which discovered the specific behavior of radioactive fall-out in soils and in plants.

V. M. Klechkovskiy carried out broad experimental, methodological, theoretical investigations which made it possible to undertake a systematic study of the behavior of microquantities of radioactive fall-out in soils, and thereby to establish the basis of a new science on the adsorption capacity of soils.

The agricultural chemical and biophysical work with radioactive fall-out led Klechkovskiy to the study of some broad theoretical questions in chemistry and in atomic-physics. During the last 10 years he published his theoretical investigations relating to the structure of the electronic envelope of atoms particularly of the atoms of elements in the middle of the periodic table of Mendeleyev. As is known there are some deviations from the normal periodicity of electronic levels of atoms (from the standpoint of the classical theory). These deviations are explained as an anomaly of the periodic system, as a breakdown of the validity of its construction as compared with some imaginary "ideal system of elements" in which the sequence of filling of quantum levels corresponds to consistent increase in the value of the principal quantum number.

V. M. Klechkovskiy as a result of careful theoretical investigations was able to solve this controversy.

He discovered a definite region of atomic states of multi-electron atoms within which the energy is determined more by the sum of the principal and of the arbitrary quantum numbers rather than only by the principal quantum number of important laws in atom spectra and in structure of electronic envelopes of atoms which give basically new solutions which make it possible to predict theoretically, with a great degree of accuracy, the distribution of atomic electrons not only at the beginning of the periodic table but throughout its extent—including that part of the periodic system in which the radioactive products of heavy nuclei (strontium, cesium, and others) and also natural radioactive elements, trans-uranium elements, and some still undiscovered heavy and super-heavy trans-actinic elements are placed.

Klechkovskiy's studies of important problems of science are widely known not only in the Soviet Union but also outside of our country. A number of his scientific works were translated into English, French, German, Chinese, Polish, Hungarian, Rumanian, and other languages.

V. M. Klechkovskiy aimed to be a deserving successor of his teacher D. N. Pryanishnikov who always quoted K. A. Timiryazev's saying "The duty of every scientist is not to try to prove the infallibility of his ideas but always to be ready to discard views which appear to be unproven, to be ready to discard all experiments which prove to be erroneous. There is someone above scientists even above most talented ones. It is science itself and its progressive revolutionary movements" (Volume 5, page 215).

Klechkovskiy paid a great deal of attention to his teaching work. He prepared numerous cadres of agricultural chemist candidates of science and doctors. Vsevolod Mavrikiyevich did a lot of work on improvements in the preparation of agricultural chemists, and in the propagation of agricultural chemical knowledge in our country.

He carried out a broad civic activity. In recent years he took part in the work of the permanent committee on radiation of the United Nations, as a member of the delegation of the Soviet Union. There he actively defended the noble proposal of our government for the outlawing of nuclear weapons and of carrying out atomic explosions. He was a member of the editorial boards of the journals "Pochvovedeniye" and "Izvestiya Timiryazevskoy sel'skokhozyaystvenoy Akademii." Klechkovskiy's civic activity is as varied as his scientific and teaching work.

The staffs of the Timiryazev Agricultural Academy of the Dokuchayev Soil Institute, Academy of Sciences, USSR, and the Editorial Board of the Journal "Pochvovedeniye" congratulate Vsevolod Mavrikiyevich on his anniversary and wish him further success in his very fruitful scientific and civic activities.

FIFTIETH ANNIVERSARY
OF YA. YA. TOMASHEVSKIY'S SCIENTIFIC ACTIVITY

The Polish Society of Soil Scientists, Union of Soil Scientists

Ya. Ya. Tomashevskiy was born on December 30, 1894 in Gantrevichi of the former Minsk guberniya. After completing the Pinsk (real'noye) secondary school he entered the Institute of Agriculture and Forestry in Pulava (Novo-Aleksandriya) in 1905. Upon completion of the course in forestry he specialized for 2 years in soil science under the direction of Professor K. D. Glinka.

In 1910 he worked in the Far East as Soil Scientist for the Amur Expedition on the preparation of the soil map of the Zeysko-Bureiaskiy watershed and on the studies of the "Amur Chernozem." From 1911 to 1922 Tomashevskiy worked in the Organization for the Stabilization of Sands and Gullies in the Ministry of Agriculture. For 11 years he carried out laboratory investigations on the experimental area of the Khoseutov area (southern part of the former Astrakhan'gub). During this period he published 9 scientific papers including 3 monographs.

In the summer of 1922 he went home to Poland where he entered the scientific Agricultural Institute at Pulava. He worked in this institute for 23 years in the fields of scientific and applied soil science, hydrology and reclamation of meadow and bog soils.

In 1945 Tomashevskiy was invited to the Chair of Soil Science of the Lyublin University. A year later he was transferred to the same Chair of the Vrotslava University where he is working at the present time conducting soil and hydrologic investigation. He is busy with the study of soil processes, and the origin and evolution of soils. In his later dealing with dynamics and the evolution of soils he is making an attempt to introduce the new bioecological approach into soil science. This is being done on the premise that the primary factor in soil formation, development and evolution is the bioecological factor.

The All Union Society of Soil Scientists congratulates Professor Tomashevskiy, honorary member of the Society, on his fifteenth anniversary of scientific activity, and wishes him many more years of fruitful work.

REPORT OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS, 1960

N. A. RAZORENOVA

The All-Union Society of Soil Scientists (VOP) carried out important scientific organizational work during 1960. The work was geared to direct the attention of Society members to participate in solving theoretical problems in soil science and agricultural chemistry and in strengthening the ties between science and production.

During the past year the Society took an active part in preparing for the Seventh International Congress of Soil Science. Active participation of Soviet scientists in the Seventh Congress resulted in the increase of their prestige in the International Arena and raised the authority of Soviet soil science.

During the past year the Society has grown further. Four new sections were organized: the Kursk, Kaluga, Kostroma, and Kirov.

As in the past, the Permanent Commissions on various sub-divisions of soil science and the Dictionary Commission carried out successful work at Headquarters.

During 1960, 9 additional members were admitted who took part in the work of the Seventh International Congress of Soil Science. At the present time membership in the International Society of Soil Science includes 70 scientists and 10 institutions of the USSR.

Activities of the Presidium and of its Organs

At meetings of the Presidium during the year the following topics were considered:

1. Reports on the activities of the Central Council of the VOP Society of Soil Scientists for 1959.

2. The work plans of the Presidium and of the Permanent Commissions were approved.

3. A report of the Organization Committee for preparation of the Seventh International Congress of Soil Science.

4. The work of the Dictionary Commission.

5. Approval of newly organized sections: Kursk, Kaluga, Kostroma and Kirov.

6. Approval of plans for the editorial preparation for 1961.

7. The Organizational Committee of VOP held 7 meetings in connection with the Seventh International Congress of Soil Science.

In addition 3 scientific conferences were conducted:

1) A meeting devoted to the commemoration of N. M. Sibirtsev. Papers on his life were presented by Yu. A. Liverovskiy and S. S. Sobolev. (Similar meetings devoted to commemorating Sibirtsev were held in the Gor'kiy and Stalingrad sections.)

2) Combined meeting with the Agronomic Section of the Scientific Technical Committee of Agriculture and Forestry. This meeting was devoted to the consideration of means for the reclamation and improvement of productivity of solonetz soils of the collective and state farms of the RSFSR.

3) A report by I. V. Tyurin entitled "The Seventh International Congress of Soil Science".

Work of the Permanent Commissions

The work of the Permanent Commissions was characterized by its considerable diversity. Along with conducting scientific conferences, the Commissions also dealt with the review and editing of papers of Soviet Scientists for the Seventh Congress. In addition, a number of Commissions continued their work in preparation of the Dictionary, and other Commissions continued work on the Explanatory Dictionary. The reports scheduled by the various Commissions dealt with problems of: water regime, composition of air in the soil, formation of secondary minerals, various phases of chemistry, biological toxicity of soils, the role of invertebrate animals in the formation of soils, the production and application of various types of fertilizer, questions of genesis and geography of soil melioration of salinized soils, and micromorphological study of loess.

In addition the Commission on Biology of Soils conducted a conference together with the Microbiological Society on the decomposition of organic matter by microorganisms, a question of great theoretical and practical value.

The Sub-Commission on Controlling Soil Erosion, together with the Ministry of Agriculture of the USSR and the Russian Society on Protection of Nature, conducted a conference on the question of controlling soil erosion and outlined a number of concrete undertakings. The conference was attended by more than 400 people.

Representatives of the Dokuchayev Soil Institute of the Academy of Sciences of the USSR, Moscow State University, Timiryazev Agricultural Academy, All-Union Institute of Fertilizer and Agricultural Soil Science, Forestry Laboratory of the Academy of Sciences of the USSR, Institute of Microbiology, Giprovodkhoz, All-Union Scientific Institute of Hydrotechniques and Amelioration, and also Representatives of the branches and sections of the society participated in work of the Commissions.

All 7 Commissions held meetings during November and December devoted to results of work of the Commissions of the Seventh International Congress of Soil Science. Reports were given by delegates who took part in the work of the Congress.

In the course of the year the 7 Commissions had 52 meetings and conferences which is considerably more than in 1959. This gave the workers of various institutions an opportunity to exchange views on various subjects under consideration.

During the past year a good deal of work was done on the Explanatory Dictionary. In 1959 the Commissions on Physics, Melioration, and on Mineralogy of Soils finished preparation of the dictionary in their divisions. In 1960 the Explanatory Dictionary in these divisions was rotoprinted and sent to various sections and branches, to a number of institutions, and to private individuals. In publishing the Explanatory Dictionary the society received a great deal of help from A. I. Marchenko, director of the Dokuchayev Central Soil Museum.

The preparation of the chemistry, biology, fertility, and soil erosion divisions of the Dictionary was finished. There remains the preparation of the division of genesis, geography, and of classification of soils.

Activities of Branches and Sections

As mentioned already, the Society is composed of 16 branches and 34 sections, with a total membership of 2,583.

The Ukrainian branch has the greatest number of members—334; the Leningrad branch—151; the Uzbek section—119; the Voronezh section—110; the Latvian branch—95; the Moldavian branch—91. In addition, there are sections where the number of members is small—from 12 to 20.

The majority of branches and sections carry out good work. Especially active during 1960 were the Belorussian, Georgian (Gruzian), Latvian, Lithuanian, Moldavian, Ukrainian, Uzbek, Northern Caucasus, and Estonian branches, and the following sections: Bashkir, Voronezh, Kazan', Kuybyshev, Kiev and Rostov. Specialists of universities and of scientific institutes and also of production organizations participated in the work of these branches and sections, the membership of which includes a considerable number of highly qualified specialists.

It is necessary to call attention to the successful work of the Ryazan', Gor'ki, Mariyskiy, Komi ASSR, and Tomsk sections which in spite of their small membership are the centers around which are grouped practical soil scientists who receive daily help and consultation from more highly qualified specialists.

Less satisfactory was the work in 1960 in the Azerbaydzhan branch and in the Altay, Sverdlovsk, Penza, and Vladivostok sections. There is no information at all on the work of the Saratov section.

Unfortunately there are a number of sections such as Kemerov, Tula, and Kagula where the membership consists of only practical soil scientists. In these cities there are no agricultural universities or scientific institutes. The work of these sections is therefore not sufficiently diversified But it should still be pointed out that the work of almost all the branches and sections in the field resulted in fruitful contacts between soil science specialists, agricultural chemists, and agronomists of various institutions and organizations. Such contacts lead to the increase of scientific knowledge of members of the society. They also aid in dissemination of scientific information in fields of soil science, and in scientific and methodological assistance to industry.

The work of the branches and sections is diverse. In addition to scientific reports an important role is played by dissemination of scientific information on soils through press, radio, lectures, consultations, and by other means.

The many reports at the conferences of the branches and sections continue to give a good deal of attention to the problems of local classification, to site quality, to the agronomic evaluation of soils, to large scale mapping, and to agricultural soil regionalization in the republics, krays, and oblasts. These activities were included in the work of all the branches and sections.

A great deal of attention was devoted to the use of fertilizer under local conditions. This subject was on the agenda of conferences of the Armenian, Belorussian, Georgian, (Gruzian), Latvian, and Lithuanian branches and of the Gor'ki, Krasnodar, Stalingrad, Rostov, and Tomsk sections. In some of the branches the use of microelements was dealt with. (Belorussian, Latvian, Lithuanian branches, and the Yakut and Rostov sections.)

The subject of controlling soil erosion was dealt with by the Armenian and Georgian (Gruzian) branches and by the Bashkir, Voronezh, Kazan', and Kuybyshev sections.

The work of the branches and sections led to a considerable increase in contacts of scientific institutions with industrial organizations. Thus in the Belorussian, Georgian, North Caucasian, Kirgizian, Lithuanian, and Ukrainian branches, and in the Bashkir, Kuybyshev, Kazan', Kiev, Voronezh, Novosibirsk, Mapiysk, Ryazan', and other sections a great deal of attention was given to industrial problems and to the work of practical soil scientists. Here the systematic lists of soils used in large scale mapping are being worked out and improved. In the course of their field work, workers of universities and of scientific experimental institutes visit experimental areas and consult with the practical soil scientists in the field.

In a number of branches: the Belorussian, Georgian, Latvian and Estonian, and in the Gor'ki, Kazan', Bashkir and other sections, members of the VOP took an active part in presenting lectures in courses and seminars organized by the Ministries of Agriculture of the Republics, or by the Regional Agricultural Offices for practical soil scientists, for workers of agricultural chemical laboratories, and for agronomists. In some of the branches and sections a great deal of attention was given to dissemination of scientific knowledge through lectures. Thus, in the Omsk section 76 lectures were delivered; in the Tomsk—21; in the Petrozavodsk—16; in the Perm—14; in the Estonian branch—17; and so forth.

Conferences and Consultations

In 1960 a number of regional conferences were held with the participation of soil scientists of neighboring republics, krays, and oblasts and also representatives from Moscow.

The Kazakh branch conducted the third republican conference in December of this year which was attended by A. A. Yerokhina, member of the Central Council and Ye. V. Lobova, Vice-President of the Fifth Commission of the International Congress of Soil Science. Also present at the conference were representatives of the Tadzhik, Kirgiz and Uzbek branches of VOP (All-Union Society of Soil Scientists).

The Voronezh Section conducted a conference on the problems of classification of soils of the Central Chernozem Belt.

The North Caucasian branch organized a scientific conference on the problems of agricultural chemical investigation of soils and of preparation of soil maps for collective farms.

The Moldavian branch held a large conference devoted to the sixtieth anniversary of the publication of Dokuchayev's "Soils of Bessarabia". This conference was attended by N. N. Rozov, member of the Central Council and senior staff member of the Soil Institute.

The Tadzhik branch together with the Institutes of Soil Science conducted a republican conference on methods and progress in large-scale mapping. The conference was attended by the representatives of the Kazakh branch of the VOP.

The Kazan', Gor'ki, Ryazan', Perm, and Novosibirsk sections took an active part in the meetings of workers of soil expeditions and of agricultural chemical laboratories which were organized by the Regional Offices of Agriculture.

In October the Kazan' Section conducted a meeting of the coordinating committee on organizational problems which dealt with the meeting of soil scientists of the southern Ural and middle Volga. The meeting was attended by representatives of the Kazan', Mariyskiy, Bashkir, Sverdlovsk and Kuybyshev sections.

The Lithuanian branch organized a 3-week expedition to the European part of the USSR. Twenty-five soil scientists took part in this trip. The itinerary was Minsk, Moscow, Rostov, Batumi, Tbilisi (Tiflis), Astrakhan', Stalingrad, Kiev, Bomel', and Kaunas. During the excursion they met local soil scientists who extended considerable help in acquainting the participants with the soils and with scientific-experimental institutions.

The year 1960 was noted by ever increasing contacts between the branches and sections of VOP. As before, the branches of the Baltic Republics—Latvia, Lithuania, and Estonia worked together.

A great deal of work was done in the Kazan' and Bashkir sections in organizing the soil scientists of the southern Ural and of the middle Volga. Contact is being established in the work of the Irkutsk and Buryat-Mongol sections, and also of the Leningrad and North Caucasus branches.

Scientific Associations with Foreign Countries

In May of this year the president of the Society, I. V. Tyurin, together with N. N. Rozov, and Ye. N. Rudneva, went to Hungary to participate in the International Conference on the preparation of soil maps of eastern and western Europe. This conference considered the coordination of the legends of the soil map of eastern Europe prepared by the Dokuchayev Institute of the Academy of Sciences of the USSR, with the participation of soil scientists of eastern Europe. I. V. Tyurin presented a general paper on this subject.

In August, 1960 the Seventh International Congress of Soil Science took place in the USA.

This was preceded by a great deal of work carried out by the Organizational Committee of VOP on the Preparation for the Seventh International Congress of Soil Science. Sixty-two papers with summaries in foreign languages and 24 papers translated in full into foreign languages were prepared and sent to the program committee of the Congress.

From the Soviet Union went a delegation consisting of 6 people and a tourist group of 20. The participants of the Congress were the representatives of: agencies of the Academies of Sciences of the USSR and of the Union Republics; the Ministry of Higher and Secondary Special Education; the Ministry of Agriculture; and the Lenin All-Union Academy of Agricultural Sciences (VASKhNIL).

Soviet scientists took an active part in work of the Congress. They read 22 papers.

I. V. Tyurin's paper "The contribution of soil science to Agricultural Production of the USSR" was included in the program of the plenary session of the Congress and was presented by him at one of the first meetings. The report created a great deal of interest among the participants.

The greatest number of papers by Soviet scientists was presented at the plenary meetings of Commission V of the International Congress of Soil Science. Great attention was given to the following papers: "Soil Map of Asia", by V. A. Kovda and Ye. V. Lobova; "Soil Map of Eastern Europe" by I. V. Tyurin, N. N. Rozov and Ye. N. Rudneva; and "Classifications of Soils and Soil Map of the USSR" by Ye. N. Ivanova and N. N. Rozov.

These papers were ordered by the program committee of the Congress. At the meetings of Commission V papers were presented by P. V. Vlasyuk, U. U. Uspanov, N. L. Blagovidov, and Ye. S. Blazhniy.

The meetings of other commissions heard papers by N. A. Kachinskiy, V. A. Frantzeson, S. N. Ryshov, L. N. Aleksandrova, D. M. Guseynov, E. A. Shtin, G. S. Davtyan, A. V. Peterburgskiy, F. V. Turchin, I. N. Antipov-Karatayev, N. P. Karpinskiy, and V. F. Shubin.

At the special session under the leadership of Soviet scientists I. V. Tyurin and V. A. Kovda, a discussion was carried out of the problems of genesis, geography, and cartography of soils and particularly of the question of classification in connection with the projects on this subject presented by Soviet and American soil scientists. Papers of Soviet scientists on soil maps of Europe and of Asia were discussed.

The Congress organized an exhibition on the achievements in the fields of cartography, soil science, agricultural chemistry, agronomy, and physics. The exhibit of the Soviet Union included: the "Soil Map of the USSR" on a scale of 1:12, 000, 000; "Soil Map of Asia" on a scale of 1:6, 000, 000; "A Scheme of Geographical Regionalization of Soils"; "Soil Map of Eastern Europe" on a scale of 1:5, 000, 000; and "Soil Map of the World" on a scale of 1:45, 000, 000 with an explanatory text.

On exhibit were a volume of papers presented by Soviet scientists at the Seventh International Congress in the USA, and a volume of papers by Latvian, Ukrainian and Tadzhik soil scientists, published especially for the Seventh International Congress of Soil Science. The Soviet Union exhibits attracted a great deal of attention.

At the end of the scientific conferences there were elections to the Administrative positions of the Eighth International Congress of Soil Science which is to be held in 1964 in Rumania. N. Chernesku was elected President of the Eighth Congress. Soviet scientists elected into the offices of the Congress included: I. V. Tyurin, President of Commission IV on Soil Fertility; Ye. N. Mishustin, Vice-President of Commission III on the Biology of Soils; and Ye. V. Lobova, Vice-President of Commission V on Genesis, Geography, and Classification of Soils.

Upon returning from the USA the delegates and tourists presented reports on the Congress at meetings of the branches and sections of VOP of which they are members.

Publications

In 1960 a volume of 32 printed sheets was published containing the papers of Soviet soil scientists prepared for the Seventh International Congress in the USA.

The second volume of the transactions of the first "Delegate's" meeting of soil scientists was also issued.

The explanatory Dictionary of soil science (division of physics, melioration and mineralogy of soils) was published in rotoprint; it was sent out to the branches and sections of VOP, to institutions, and to private persons for review and suggestions.

The Latvian, Ukrainian and the Tadzhik branches (as was mentioned already) issued a volume of papers prepared for the Seventh International Congress of Soil Science.

The Bashkir section of VOP continued the publication of Volumes 3 and 4 of Soils of the Urals and the Volga."

In press is a monograph by S. P. Yarkov entitled "Soils of the Forests Meadow Zone."

The Latvian branch prepared a volume of papers by members of the branch in connection with the 20th anniversary of Soviet Latvia.

SYMPOSIUM ON SOIL FAUNA IN VIENNA

M. S. GILYAROV

During the International Entomological Congress (August 22-23, 1960) in Vienna, a symposium was held on soil fauna. The symposium was organized by the zoological committee of the International Society of Soil Scientists. (The chairman-organizer was Professor Herbert Frantz of Vienna.) The symposium was attended by 50 scientists of various countries. The Soviet specialists included the following: T. G. Grigor'yeva (Leningrad), Ye. M. Zakhvatkina (Moscow), A. I. Zrazhevskiy (Kiev), D. N. Kobakhidze (Tbilisi), A. I. Cherepanov (Novosibirsk), and others.

The introductory paper was given by Dr. J. Balogh of Budapest, Hungary. In this paper he emphasized the growing role of soil-zoological investigations in solving problems in soil science and agronomy of various countries. He also demonstrated the evolution of soil-zoology into an independent discipline. Balogh's report dwelt on the basic tasks of soil-zoology which were stressed repeatedly by this author in our Russian literature including the Journal "Pochvovedeniye."

Dr. S. D. Selga of Madrid, Spain showed how the number of "collembols" in meadow soils is changed with the regime of utilization of the grass cover and with the influence of fertilizers.

Dr. G. Marcuzzi of Padua, Italy, traced the distribution of microarthropods in the soils of the southeastern Alps at elevations from 1400-2300 meters. He found that ticks predominate in the complex of microarthropods of forest, while in soils of meadow associations the numbers of ticks and of collembols are approximately the same. This conclusion is similar to our data obtained for the Fergana Mountain range.

In a paper by us the laws governing the changes in soil fauna under litter in various parts of the steppe zone are traced. It was shown that the composition and vertical distribution of invertebrates in the soil reflect a tendency towards moistening of the upper horizons under forest cover. Professor A. I. Zrazhevskiy showed that regions of mass distribution and mass reproduction of the sugar beet weevil in the Ukraine have soils with a definite texture and composition.

Dr. D. I. McE. Kevan of McDonald, Canada reported that in his country the soil zoological investigations are only beginning to develop. Work carried out previously was important only in controlling pests or injurious organisms, and was devoted to the solution of taxonomic and systematic problems.

Dr. J. B. Kring of New Haven, Connecticut, USA studied the relation of the rhythm of nutrition, of rest, and of molting of larvae of the click beetle to seasonal conditions. It appears that when larvae are kept under strictly constant conditions they exhibit a rhythmic activity which is regulated by internal factors. This activity corresponds to the seasons but it can be altered by changing the environment. The data relating to the need of larvae for animal food are interesting. The conclusions are analogous to those reached by V. G. Dolin (Kiev).

A substantial review of investigations of beetles in all stages of their development while in the soil was given by Professor H. Coiffait of Toulouse, France. He elucidated in detail the characteristics which are common to pedobionts and troglobiont, and to dwellers of cracks.

Dr. H. U. Thiele of Cologne, Western Germany reported data showing that there is a constant correlation between the dates of reproduction and places of habitation (forests or fields) of carabides.

Dr. W. Dunger of Gerliz, East Germany discussed in detail his work on the discriminative feeding of invertebrate-saprophages of soil and litter. Contrary to former opinions they are quite finicky as far as food is concerned; they feed only on plant litter. Different types prefer the residues and litter of different plants. The discussant showed what an enormous amount of work (expressed in precise quantitative terms) is done by invertebrates in the process of decomposition of forest litter.

In the reports by E. Horber of Zurich, Switzerland there was given material on the utilization of radioactive tracers in the study of the ecology of soil pests (mole-cricket, skipjack, and larvae of cockchafer), and on developing methods of combatting them. Horber dwelt particularly on the experiments with tracers, which were quite similar to those carried out previously in the Soviet Union by Professor A. I. Charepanov (Novosibirsk).

After the symposium there was a meeting of the Committee on Zoology of the International Association of Soil Scientists at which it was decided to organize a colloquium on the "Interrelationship between Micro-flora and Soil Fauna." The Colloquium will be held in Arnheim, Holland during the first week of September, 1962. Papers must be presented in one of the following languages: English, German, or French. They must have summaries in English. The deadline for submitting papers will be not later than 3 months prior to the date of the Colloquium. Dues were set at 50 Dutch Guilders. The secretary of the Colloquium is Dr. I. Vander Drift of Wagenningen, Holland.

During this Symposium the participants had an opportunity to get acquainted with the major soil zoological centers of Vienna—the Laboratory of Professor W. Kühnelt (the Second Zoological Institute of Vienna University), and the Chair of Professor H. Franz, (Institute of Geology and Soil Science of the Higher Agricultural School). Kühnelt's work is essentially in the field of physiology and autecology of a number of soil insects. The work of Franz, on the other hand, is principally on the characteristics of the fauna of different types of soil particularly in the northeastern Alps.

The work of the Symposium and the papers on soil insects at the Eleventh International Entomological Congress demonstrated the interest of investigators in problems of soil ecology.

LETTER TO THE EDITOR—OPEN-PIT WORKINGS OF USEFUL MINERALS AND THE QUESTION OF PROTECTING SOIL RESOURCES OF THE COUNTRY

S. A. ARISTOV

Open-pit mining of useful minerals is at the present time assuming considerable importance in the Soviet Union.

With the growth of industrial and housing construction, the construction-materials industry has developed rapidly. Cement factories, glass and ceramic industries, and factories for reinforced concrete are being built. All of them have their own pits for mining the required raw materials.

Existing mining enterprises which serve the metallurgical and chemical industries, and supply construction materials are increasing their open-pit areas. The increase in the scale of open pits leads to leases of new areas for mining purposes, and eventually to their irretrievable loss. Hopelessly spoiled are not only the areas under excavation but also the areas under tailing. Present methods of open-pit mining do not provide for saving of the soil layer; yet the soil, especially chernozem, is in many cases not less valuable than the minerals underlying these areas. V. V. Dokuchayev stated that the chernozem constitutes a treasure of the Russian people and that the value of the chernozem soils is higher than that of any mineral. The Germans organized the transport of chernozem to Germany from the occupied territory of the European part of the USSR.

It should be pointed out that many of the active open pits and new plants of the construction-materials industry are in the Ukraine and in southern Russia; that is, in the territory with most productive chernozem soils and with favorable climate.

The extent of the damage done from open-pit mining of minerals can be assessed provisionally with the following data: A pit of average size (productivity) occupied an area of several tens of hectares. A comparable area is occupied by the tailings. Such great works as the pits of the Kursk magnetic anomaly occupy hundreds of hectares. With thousands of pits in the country every year we are losing tens of thousands of hectares of cultivated land suitable for agriculture.

Thus, our losses of arable land as a result of development of the mining industry is no less serious than those caused by soil erosion.

To save the soil where open pits are operated the following measures can be taken:

1. When the pit is planned the question of subsequent utilization of the tailings after the pits are liquidated must be given serious consideration.

2. The present method of working open pits must be changed so as to provide for the saving of the top soil in separate piles.

3. When the pit is abandoned the soil layer must be restored on the leveled tailings and on the area of the pit.

4. The soil areas must be returned to agricultural use as they are being restored.

ALEKSANDR VASIL'YEVICH MUKHLYA (1887-1960)

The Staff of the Chair of Soil Science, Kazakh Agricultural Institute

On the fourteenth of September 1960, one of the oldest workers of the Kazakh Agricultural Institute, an honored scientific worker of the Kazakh SSR, Doctor of Agricultural Sciences, Professor Aleksandr Vasil'yevich Mukhlya died after a long illness.

A. V. Mukhlya was born on September 14, 1887 in the city of Alma Ata (formerly Verniy). After completing the Agricultural Institute Aleksandr Vasil'yevich specialized in soil science and devoted 40 years of his fruitful life to the study of the soils of Kazakhstan. He investigated the soils of: Semirech'ye Bet-Pak-Dala, Southern Kazakhstan, and of the valleys of the Syr-Dar'ya, Chu and Ili Rivers. With the data of these investigations Mukhlya published almost 30 papers and special works including the well known "Soils of Dzhetisu" (1929), "Irrigation of Crops of Kazakhstan" (1934), "Soils of the Golodnaya Steppe, their Melioration and Use" (1935), "Soils of Kazakhstan and their Agricultural Utilization" (1936), "Principles of Geology and Mineralogy" (1957) and others.

In his doctor's thesis "Desert Blocks (Massifs) of Central Kazakhstan" (1947), A. V. Mukhlya elucidated the natural and soil conditions of Bet-Pak-Dala and suggested means of their rational use for the development of range management.

Aleksandr Vasil'yevich successfully combined scientific work with teaching activity. Over a period of 25 years he was in charge of the Chair of Soil Science of the Kazakh Agricultural Institute. He lectured to 20 classes of agronomists, 10 classes of hydraulic engineers, and to 3 classes of foresters.

Many students who attended the Students Scientific Club of Soil Science organized and headed by A. B. Mukhlya became qualified soil scientists and are now working in scientific-experimental institutes and in universities of the Republic.

The Soviet government greatly valued the contribution of A. B. Mukhlya and honored him with the order of the "Red Banner of Work," and the "Sign of Honor." He was given the title of "Honored Scientific Worker" of the Kazakh SSR. More than 10 times he was elected as deputy to the Alma Ata city council of workers.

An exceptional teacher and a scientist-communist was lost.

The bright memory of Aleksandr Vasil'yevich will remain for a long time with his students and colleagues.

BIBLIOGRAPHY

FACTORS OF SOIL FORMATION, GENESIS, AND GEOGRAPHY OF SOILS

1. BARANOVSKAYA, A. V. 1960. Seasonal variability of chemical properties of the soil of the forest zone. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 203-255, with tables. Bibliog. pp. 253-255.

2. IVANOV, N. A. 1960. Soils of the southeastern part of the Kurgan Oblast' (Materials on characteristics). Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 95-104. Bibliog. 12 refs.

3. ZAVALISHIN, A. A., and V. P. FIRSOVA. 1960. A study of the genesis of Podzolic type soil on clay loam deposits of the central part of the Russian Plain. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 7-95. Bibliog. pp. 94-95.

4. ZOLOTAREV, S. A. 1960. Genesis of forest soils and of oak forests of the Far East. Vopr. geogr. Dal'nego Vostoka, sb. 4, pp. 174-184. Bibliog. 17 refs.

5. KARAVAYEV, V. N. 1960. Soils and relief of Udmurtiya (Materials on genetic characteristics). Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 115-120. Bibliog. 13 refs.

6. KACHIYANI, A. I. 1960. Economic evaluation of the soils of the Khabarovsk region. Vopr. geogr. Dal'nego Vostoka, sb. 4, pp. 24-54. Bibliog. 5 refs.

7. KOVDA, V. A., V. V. YEGOROV, V. S. MURATOVA, and B. P. STROGONOV. 1960. Classification of soil according to degree and quality of salinization in connection with salt tolerance of plants. Botan. zh., vol. 45, No. 8, pp. 1123-1131. Bibliog. p. 1131.

8. KREYDA, N. A. 1960. Material soil regionalization of the northern Russian plain. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 113-123, with maps. Bibliog. p. 123.

9. General natural and soil conditions of Agricultural Production of the Oblasts of Kazakhstan. Tr. In-ta pochvovedeniya Akad. Nauk KazSSR, vol. 10, Contents: Matusevich, S. P., Akmolinskaya Oblast', pp. 5-14. Bibliog. 5 refs.; Petelina, A. M., Aktyubinskaya Oblast', pp. 15-30, with map. Bibliog. 7 refs.; Sokolov, S. I., and I. A. Assing, Alma-Atinskaya Oblast', pp. 31-48, Bibliog. pp. 47-48; Sokolov, A. A., East-Kazakhstan Oblast', pp. 49-72, with map; Dupasov, A. M., and S. I. Sokolov, Guryevskaya Oblast', pp. 73-87 with map. Bibliog. pp. 86-87; Assing, I. A., and M. S. Golovkina, Dzhambul'skaya Oblast', pp. 88-97, with map. Bibliog. p. 97; Borovskiy, V. M., and K. Ya. Kozhevnikov, West-Kazakhstan Oblast', pp. 98-111, with map. Bibliog. 17 refs.; Storozhenko, D. M., and I. V. Matishuk, Karagandinskaya Oblast', pp. 112-130, with map. Bibliog. p. 130; Borovskiy, V. M., Kzyl-Ordinskaya Oblast', pp. 131-144, with map. Bibliog. p. 144; Pachikhina, L. I., and M. I. Rubinshteyn, Kokchetavskaya Oblast', pp. 145-158, with map. Bibliog. p. 158; Uspanov, U. U., and Yu. G. Yevstifeyev, Kustanayskaya Oblast', pp. 159-177. Bibliog. 13 refs; Durasov, A. M., Pavlodarskaya Oblast', pp. 178-193, with map. Bibliog. 40 refs.; Fedorin, Yu. V., North-Kazakhstan Oblast', pp. 194-200, Bibliog. 199-200; Gudinov, N. B., Semipalatinskaya Oblast', pp. 201-211, with map. Bibliog. 8 refs. Serpikov, S. K., Taldy-Kurganskaya Oblast', pp. 212-226, with map. Bibliog. pp. 225-226; Vyatkin, M. K., South-Kazakhstan Oblast', pp. 227-242. Bibliog. 14 refs.

10. PONOMAREVA, V. V. 1959. Regularities of soil formation in the Karelian isthmus and some general questions of soil formation. In: Sovremennyye pochvennyye protsessy v lesnoy zone Yevr. chasti SSSR, Moscow. Izd. Akad. Nauk SSSR, pp. 204-219, with illustr. Bibliog. 18 refs.

11. ROZHNOVA, T. A. 1960. Characteristics of the soil regions of Karelian isthmus. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 96-112. Bibliog. p. 112.

12. SKRYNNIKOVA, I. N. 1959. Soil solutions of the southern part of the forest zone and their role in contemporary processes of podzol formation. In: Sovremennyye pochvennyye protsessy v lesnoy zone, Yevr. chasti SSSR. Moscow, Izd. Akad. Nauk SSSR, pp. 50-169, with illustr. Bibliog.

147 refs.

13. SOKOLOV, A. A., and K. SH. FAIZOV. 1960. Solods of the Middle Irtysh. Izv. Akad. Nauk KazSSR. Ser. bot. i pochvoved., vyp. 3, pp. 3-19. Summary in Kazakh. Bibliog. pp. 18-19.

14. STEPANOV, I. S. 1960. Classification of cultivated treatments of sod-moderately podzolic coarse clay loam soils. Izv. Timiryazev. s.-kh. akad., vyp., pp. 204-213. Bibliog. pp. 212-213.

15. Steppe and leso-steppe soils of the Buryat ASSR and their Agricultural production characteristics. Izd. Akad. Nauk SSSR, 1960. 151 p. (Izd. Akad. Nauk SSSR Pochv. in-t im. Dokuchayeva). Contents: Ufimtseva, K. A., Steppe and forest-steppe soils of Buryatskaya ASSR, pp. 5-137, with map, Bibliog. 39 refs.; Vazhenin, I. G., V. N. Doryugina, N. A. Kochina, and K. A. Ufimtseva, Agricultural productivity characteristics of cultivated soil of the Buryatskaya ASSR, pp. 138-150.

16. CHAMEYEV, K. V. 1960. Soil conditions of virgin lands of the forest-steppe regions of the Sverdlovsk Oblast' and propects for their utilization. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 89-93. Bibliog. 7 refs.

17. GALLOWAY, H. M. 1959. Soil survey of Pawnee County, Oklahoma. U. S. Dept. Agric. Soil Conservat. Serv. Soil Surv. 1952. No. 4, pp. 1-71.

18. GIDDENS, J., et al. 1960. Soils of Georgia. Soil Sci., 89(4):229-238.

19. GUSTIUC, L., and D. MAROLA. The effect of microrelief on the salinization process of soils in the Chilia hills. Inst. agron. "I. Ionescu de la Brad" Iasi. Luc. stiint. pp. 13-22. (In Rumanian).

20. GUSTIUC, L. 1959. Proposition for the classification of alluvial grassland soils of the rivers in the Rumanian People's Republic. Inst. agron. "I. Ionescu de la Brad", Iasi. Luc. stiint., pp. 5-11. (In Rumanian).

21. FREI, E. Bodenkartierung und Landwirtschaft. Landwirtsch. Jahrh. Schweiz., 8 (4):341-360.

22. PIERCE, RYAN. 1960. Soil survey in Ireland with particular reference to forestry. Irish Forestry, 27(1):26-36.

23. WILSON, K. 1960. The time factor in the development of dune soils at South Haven Peninsula, Dorest. J. Ecology, 48(2): 341-360. Bibliog. 18 refs.

SOIL MINERALOGY

24. GROMOV, V. V. 1960. Description of micro-quantities of strontium and cesium from montmorillonite and kaolinite. Zhurn. fiz. khimii, vol. 34, vyp. 6, pp. 1366-1342. Bibliog. 9 refs.

25. BLUEMEL, F., et al. 1960. Die Mikromorphologie und der Kolloidzustand unterschiedlicher Bodentypen. Festsehr. sechsigjähr. Best. land. —chem. Bundes —Vers. Anst. Linz., 1959, pp. 89-120. Ref.: Soil and Fertilizers, 1960, No. 5, p. 2129.

26. CASTRO DE, et al. 1959. Mineralogical composition and formation of some soils in Spanish continental Guinea. An. Edafol y Fisiol Veg., 18(2):97-135. No. 3, pp. 185-206.

27. DE MUMBRUM, L. E., and R. R. BRUCE. 1960. Mineralogy of three soils of the Mississippi River alluvial plain. Soil Sci., 89(6):333-337.

28. MASUI, J. 1969. 1. Clay minerals in the soil derived from Tertiary tuffaceous rocks 2. Upland soil from the Matsushima District, Miyagi Prefecture, Japan. 3. Paddy Soil from the Matsushima District, Miyagi Prefecture, Japan. Tohoku J. Agric. Res., 1959, 10(1):15-27, No. 2:151-163. Ref.: Biolog. Abstr., 1960, No. 17, r. 48940, r. 38941.

29. SWINDALE, L. D. 1959. A one-dimensional Fourier investigation of a soil montmorillonite. N. Z. J. Ged. Geophys., No. 2: 342-349.

PHYSICAL PROPERTIES OF SOILS, METHODS OF INVESTIGATION

30. ABRAMOVA, M. M., and A. F. BOL'SHAKOV. 1960. Question of the agrohydrologic role of clean fallow. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 50-57. Bibliog. 7 refs.

31. ANTIPOV-KARATAYEV, I. N., and V. V. KELLERMAN. Soil aggregate and its colloidal-chemical analysis. Ibid., pp. 121-130.

32. AFANAS'YEV, N. I., F. YE. KOLYASEV, and B. N. MICHURIN. Water-physical conditions in the soil with water supply irrigation in Rostov Oblast'. Ibid., pp. 70-76. Bibliog. 13 refs.

33. VASIL'YEV, I. S. 1959. Water regime of forest and cultivated sod-podzolic soils. In: Sovremennyye pochvennyye protsessy v lesnoy zone Yevr. chasti SSSR. Moscow, Izd. Akad. Nauk SSSR, pp. 3-49, with illustr. Bibliog. 22 refs.

34. VERSHININ, P. V. 1960. Device for determining water-stability of soil structure. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 175-178.

35. VERSHININ, P. V. 1960. The problem of artificial structure formation. Ibid., pp. 131-143. Bibliog. 21 refs.

36. DIMO, V. N. Question of artificial soil-structure. Ibid., pp. 153-160. Bibliog. 13 refs.

37. DOTSENKO, L. S. Significance of the dry layer in the evaporation of moisture from sand. Ibid., pp. 44-49. Bibliog. 8 refs.

38. ZHUCHENKOV, K. K. Water regime and physical conditions in the soil when virgin lands are cultivated. Ibid., pp. 58-69, Bibliog. 6 refs.

39. KACHINSKIY, N. A. Nature of mechanical stability and of water stability of soil structure in connection with its genesis. Ibid., pp. 111-120. Bibliog. 58 refs.

40. KOLYASEV, F. YE., and A. G. KHOLODOV. Hydrophobic soil as a method of hydro-thermo-electric insulation. Ibid., pp. 103-110. Bibliog. 16 refs.

41. KOSOLAPOVA, N. A. 1960. Computation of release of water from snow during snow melt in the spring. Tr. Vsesoyuzn. n.-i. in-ta gidrotekhn. i melioratsii, vol. 35, pp. 39-50.

42. KUZNETSOV, S. P. 1960. Improvement of the microclimate of the water regime of soils of the Amur. Vopr. geogr. Dal'nego Vostoka, collection 4, pp. 158-173.

43. POPOV, N. 1960. Freezing and thawing of moisture in the soil. S. kh. Sibiri, No. 9:17-21.

44. POYASOV, V. P. 1960. Diffusion of carbon dioxide in the soil. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 190-209. Bibliog. 11 refs.

45. REVUT, I. B. Twenty-five years of the agrophysical scientific Institute. Ibid., pp. 3-15.

46. REVUT, I. B., N. G. ZAKHAROV, L. S. DOTSENKO, and A. V. SUDAKOV. Water regime in shifting sand when stabilized by afforestation. Ibid., pp. 32-43. Bibliog. 24 refs.

47. RODE, A. A. Question of the nature and origin of "the dead horizon of drying": in soil-ground mass of leso-steppe, steppe, semidesert and desert zones. Ibid., pp. 16-24. Bibliog. 12 refs.

48. ROZHANSKAYA, O. D., and V. A. KOLYASEVA. Heat balance and microclimate of warmed ground when covered with a light polyethylene film. Ibid., pp. 264-273. Bibliog. 7 refs.

49. ṘYZHOV, S. N., and N. F. BESPALOV. Rate of flow of moisture and of movement of salts into surface layers of soil in the light sierozems of Golodnaya Steppe. Ibid., pp. 25-31. Bibliog. 16 refs.

50. SELIVANOV, A. P. Study of water-stable aggregates in the soil. Ibid., pp. 179-189. Bibliog. 9 refs.

51. TRUSHIN, V. F. 1960. Effect of basic tillage on the temperature of the soil. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 157-163.

52. TYULINA, T. V. 1960. Dynamics of water-stability of soil structure on virgin land of Kazakhstan in connection with their tillage. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 170-174.

53. FATEYEV, N. P. 1960. Measurements of soil surface temperatures by the zero radiation method. Tr. Glav. geofiz. observatorii, vyp. 108, pp. 59-63. Bibliog. 6 refs.

54. CHUDNOVSKIY, A. F., and YU. L. ROZENSHTOK. 1960. Automatic registration of evaporation from an agricultural field. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 217-222. Bibliog. 7 refs.

55. BAVEL, C. H. M. VAN. 1959. Drought and water surplus in agricultural soils of the lower Mississippi Valley area. Tech. Bull. U. S. Dept. Agric., No. 1209:1-93.

56. DAIBOR, K. 1960. Verlagerung von Bodenstandteilen unter einen Gebirgshochmoor. Z. Pflanzenernähr., Düng., Bodenkunde, 89(134):1, pp. 55-61. Bibliog. 14 refs.

57. HAMMOND, L. C. 1959. The neutron method of measuring the moisture content of Florida soils. Proc. Florida State Hort. Soc., 72:214-217.

58. MERIAUX, S. 1960. Economie de l'eau en saison sèche dans les sols de la région de Dijon. Compt. rend. hébd. Séanc. Acad. Agric. France, 46(8):491-498.

59. RAUZI, F. 1960. Water-intake studies on range soils at three locations in the Northern plains. J. Range Management, 13(4): 179-184. Bibliog. 9 refs.

60. STOTZKY, G. 1960. A simple method for the determination of the respiratory quotient of soils. Canad. J. Microb. 6(4):439-452. Bibliog. 31 refs.

61. TISDALL, A. L. 1960. Water. J. Austr. Inst. Agric. Sci., 26(2):199-205.

62. TRENEL, M. 1960. Ueber Kondensationsvorgänge im Boden. 2. Z. Pflanzenernähr., Düng., Bodenkunde, 89(134)2 3:170-180.

SOIL CHEMISTRY AND METHODS OF ANALYSIS

63. ALESHIN, S. N., and A. I. GORB. 1960. Determination of adsorbed sodium in soils. Izv. Timiryazevskoy s.-kh. akad., vyp. 4, pp. 88-97. Bibliog. pp. 96-97.

64. AREF'YEVA, Z. N. 1960. Content of mobile manganese in various types of soils of the Urals. Tr. Sverdl. s.-kh. in-ta, vol. 7: 105-106. Bibliog. 6 refs.

65. ASTVATSATRYAN, B. N. 1960. Potassium fixation in semidesert stoney soils in the foothill zone of Armenia. Doklady Akad. Nauk ArmSSR, 30(4):235-238. In Armenian.

6. YEMEL'YANOV, I. I. 1960. Dynamics of oxidation-reduction conditions of long cultivated dark-chestnut soils of Akmolinskaya Oblast'. Izv. Akad. Nauk Kaz SSR. Ser. bot. i pochvoved., vyp. 3, pp. 32-41. Summary in Kazakh language. Bibliog. 20 refs.

7. IVANOV, S. N., and I. P. VIL'GUSEVICH. 1960. Investigations in the field of physics and chemistry of soils. . Sb. nauchn. tr. (Belorusk. n.-i. in-t zemledeliya Akad. s.-kh. nauk BSSR), vyp. 6, pp. 56-63. Bibliog. 25 refs.

8. KAMILOV, O. 1960. Mineralization of ground water in the southern part of Golodnaya Steppe. S. kh. Uzbekistana. No. 8:56-59.

9. KUKLINA, L. A. 1960. On the chemical composition of soils of coniferous forest of the North Ural. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 107-114. Bibliog. 14 refs.

0. LIKHOLAT, V. D. 1960. Some chemical problems of soils and water of the Amur. Vopr. geogr. Dal'nego Vostoka, collection 4, pp. 146-157.

1. ORLOV, D. S., and N. V. NESTERENKO 1960. Formation of humates of cobalt, nickel, copper, and zinc. Nauchn. dokl. vyssh. shkoly. Biol. nauki, No. 3:195-198. Bibliog. pp. 197-198.

2. PERSHINA, M. N., V. B. IL'IN, and S. N. SELYAKOV. 1960. Fractional composition of the humus of chestnut soils of Central Kulunda. Izv. Timiryazevskoy s.-kh. akad., vyp. 4, pp. 73-81. Bibliog. pp. 80-81.

3. PETERBURGSKIY, A. V., and F. V. YANISHEVSKIY. Leaching of potassium from the plow horizon. Ibid., pp. 82-87. Bibliog. pp. 86-87.

4. PETROVA, YU. N., and N. F. KASATKINA. 1960. Humic acid of dispersed organic matter of rocks. Tr. Vsesoyuzn. n.-i. geol.-razved. in-ta, vyp. 155. Geokhim. sb., No. 6:28-35. Bibliog. 10 refs.

5. PONOMAREVA, V. V., and T. A. NIKOLAYEVA. 1959. Methods of study of organic matter in peat-bog soils. In: Sovremennyye pochvennyye protsessy v lesnoy zone Yevrop. chasti SSSR. Moscow, Izd. Akad. Nauk SSSR, pp. 170-204, with illust. Bibliog. 8 refs.

6. STOLYAROV, K. P., and V. I. DRACHEV. 1960. Photometric method of determining small amounts of copper in soils and ashes of plants. Uchen. zap. Leningr. un-ta, No. 297. Ser. khim. nauk, vyp. 19, pp. 162-169. Bibliog. 15 refs.

7. TIMOFEYEVA, N. A., and A. A. TITLYANOVA. 1959. Adsorption by the soil of radioactive isotopes (cobalt-60, strontium-90, itrium-90, rathenium-106, cesium-137, and Zeridium-144). Tr. Ural'sk. otd. Mosk. o-va ispyt. prirody, vyp. 2, pp. 195-199. Bibliog. 7 refs.

78. TUMANOV, A. A., and P. S. KHAZANOV. 1958. Determination of potassium in solutions by its natural radioactivity. Tr. khimii i khim. tekhnologii, vyp. 2, pp. 413-418. Bibliog. 18 refs.

79. TURKIN, YU. I., and P. F. SVISTOY. 1960. Determination of magnesium in solutions by the flame photometric method [Analysis of the composition of atmosphere precipitation], Tr. Glav. geofiz. observatorii, vyp. 108, pp. 86-90. Bibliog. 12 refs.

80. SHARAPOV, I. D. 1960. Oxidation-reduction potential in soils of rice rotation. Izv. Akad. Nauk KazSSR, Ser. botan. i pochvoved., vyp. 3, pp. 20-31. Summary in Kazakh language. Biblio. 20 refs.

81. ANTOSZEWSKI, R., and J. S. KNYPL. 1960. A chemichromatographie micromethod of determining phosphorus. Mikrochim. Acts, No. 3, pp. 325-331.

82. ARNOLD, P. W. 1960. Nature and mode of weathering of soil-potassium reserves. J. Sci. Food Agric., 11(6):285-292.

83. BARDSLEY, C. E., and J. D. LANCASTER. 1960. Determination of reserve sulfur and soluble sulfates in soils. Soil Sci. Soc. America Proc., 24(4):265-268.

84. BLAKEMARE, L. C., and A. J. METSON. 1960. Micro-determination of cationexchange capacity and total exchangeable bases. Soil Sci., 89(4):202-208.

85. BROWN, W. E. 1960. Behavior of slightly soluble calcium phosphates as revealed by phase-equilibrium calculation. Soil Sci., 90(1):51-57.

86. GALLEGO, R., and S. OLIVER. 1959. Studies on iodine in soils. An edofol. y fisiol. veget. 18(3):207-238.

87. GALLEGO, R., and S. OLIVER. Relations between iodine contents and the composition of soils. No. 4:275-288.

88. GALLEGO, R., and C. BUENO. Contents and distribution of manganese in soils of central and northern Spain (in Spanish, summary in English). Ibid., No. 5:347-388.

89. GALLEGO, R., and C. BUENO. Comparative study of manganese contents in rocks, sands and clayey materials. Ibid., No. 6: 463-471.

90. GALLEGO, R., and E. LABORDA. Studies on the distribution of iron in soils and its relation to other factors. Ibid., No. 7 8, pp. 547-582.

91. HEALEY, J. J. 1960. Potassium in the soil. Better Crops Plant Food, 55 (3):10-13.

92. HSU, P. H., and M. L. JACKSON. 1960. Inorganic phosphate transformations by chemical weathering in soils as influenced

by pH. Soil Sci., 90(1):16-24. Bibliog. p. 23-24.

93. HUFFMAN, E. C., et al. 1960. Rates and mechanisms of dissolution of some ferric phosphates. Soil Sci., 90(1):8-15.

94. HUNT, E. C., et al. 1960. Field determination of beryllium in soils for geochemical prospecting. Bull. Inst. Mining, Met., No. 641:361-369.

95. ISLAM, M. A., and A. A. CHOUDHURY. 1960. Distribution of iron, manganese and phosphorus in the paddy soil profile, J. Agric. Sci., 54(3):318-320.

96. KHIN, A., and G. W. LEEPER. 1960. Modifications in Chang and Jackson's procedure for fractionating soil's phosphorus. Agrochimica, 4(3):246-254.

97. LESSAINT, P. 1960. Etude expérimentale de la mobilisation du fer des sols. (Sous l'influence des litières forestières). Compt. rend Acad. Agric. France, 46(9):564.

98. LONG, M. I. E., and G. W. WINSER. 1960. Isolation of some urea-formaldehyde compounds and their decomposition in soil. J. Sci. Food Agric., 11(8):441-445.

99. REICHENBACH, H., and B. SCHROEDER. 1960. Ein Vergleich verschiedener Methoden zur Bestimmung des Kaliumfestlegungsvermögens and einigen schleswig-holsteinischen Böden Z. Pflanzenernähr., Düng., Bodenkunde, 90(135), 1 2, pp. 116-132. Bibliog. pp. 131-132.

100. SCHEFFER, F., et al. 1960. Ueber die schonende Gewinnung natürlicher Huminstoffe mit Hilfe milder organischer Lösungsmittel. Z. Pflanzenernähr., Dung., Bodenkunde, 90 135 , (1):58-69.

101. Soil testing demands true samples. 1960. Better Crops plant Food, 44(3):36-38.

BIOLOGY AND MICROBIOLOGY OF SOILS

102. ARISTOVSKAYA, T. V. 1960. Experience with the use of the principle of flowing culture to the study of microorganisms of the soil. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 304-311. Bibliog. p. 311.

103. BYKOVA, L. N., and N. G. ZYRIN. 1960. Importance of roots of grasses in the circulation of nitrogen and of ash elements. Vestn. Mosk. un-ta, Ser. 6. Biol., pochvoved., No. 3:67-75. Bibliog. 13 refs.

104. BYCHKOVSKAYA, A. L. 1960. Methodology of exposure and quantitative determination of soil microorganisms which decompose some low molecular fatty acids. Tr. Vsesoyuzn. n.-i. in-ta s.-kh. mikrobiol., vol. 16, pp. 45-51. Bibliog. 5 refs.

105. VIGILEVA, A. I. Interrelationship of nodule bacteria and azotobacter. Ibid., pp. 86-93. Bibliog. 7 refs.

106. VOZNYAKOVSKAYA, YU. M., and G. K. ZHIL'TOSOVA. Conditions determining the composition of the microflora of various plants. Ibid., pp. 15-30. Bibliog. 47 refs.

107. DARAGAN-SUSHCHOVA, A. YU. 1960. Som data on the dynamics of biological forms of nitrogen in the soils of the Vologda Oblast'. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 293-303. Bibliog. p. 303.

108. YERMILOV, G. B. 1960. Soil microorganis as one of the causes of lowering germination of clover seed. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 295-299. Bibliog. 11 refs.

109. KIRSANINA, YE. F., and V. A. VOLKOVA. 1960. Some data on the propagation of azotobacter in soils of Gorno-Altay autonomous oblast'. Mikrobiologiya, vol. 29, vyp. 4, pp. 551-554.

110. KOLKER, I. I., and YE. N. DAKHNOVA. Propagation of azotobacter in the soils of Crimea. Ibid., pp. 555-562. Bibliog. p. 561.

111. KRYM, I. YA. 1960. Role of roots of perennial grasses in humus formation and in the accumulation of ash elements (according to materials of the investigation of some meadows of the Vologda Oblast'). Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 256-292. Bibliog p. 292.

112. KRUGLOV, YU. V. 1960. Role of microorganisms in plant nutrition. Tr. Vsesoyu n.-i. in-ta s.-kh. mikrobiol., vol. 16, pp. 30-38. Bibliog. 14 refs.

113. KUZNETSOV, V. D. 1960. Actinomycetes of some soils of the Pamir and their antagonistic properties. Mikrobiologiya, vol. 29, vyp. 4, pp. 563-570, with table. Bibliog. pp. 569-570.

114. NIKITINA, YE. A., and M. U. ABENOVA. 1960. Study of soil-microbiological conditions of plant growth on newly utilized soils of the sod-podzolic zone. Tr. Vsesoyuzn. n.-i. in-ta s.-kh. mikrobiol., vol. 16, pp. 5-14.

115. PARINKINA, O. M. 1960. Some data about oligonitrophilic microorganisms of podzolic soils. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 312-324. Bibliog. p. 324.

116. PUMPYANSKAYA, L. V., and G. A. GLOBUS 1960. Study of silicate bacteria and interrelationship with azotobacter. Tr. Vsesoyuzn. n.-i. in-ta s.-kh. mikrobiol., vol. 16, pp. 74-85. Bibliog. 13 refs.

117. SAMOYLOV, I. I., N. V. KOZLOVA, and I. P. RUSINOVA. Activity of catalase in different varieties of peat. Ibid., pp. 109-115. Bibliog. 13 refs.

118. SAMOYLOV, I. I., N. V. KOZLOVA, I. P. RUSINOVA, and YU. V. KRUGLOV. The

significance of different amounts of lime and of time of its interaction with peat in the evaluation of its biological activity of peat-lime fertilizers. Ibid., pp. 123-135.

19. SURMAN, I. I. Ability of silicate bacteria to enrich the nutrient medium with free phosphoric acids, extracted by them from difficulty available sources of phosphorus. Ibid., pp. 39-44. Bibliog. 17 refs.

20. FEDOROV, M. V., and T. K. IL'INA. 1960. Relation of separate forms of soil actinomycetes to various sources of carbon when grown on micro and molecular nitrogen. Mikrobiologiya, vol. 29, vyp. 4, pp. 494-500.

21. EFENDIYEVA, S. A. 1960. Interrelationships of azotobacter with various epiphytic microorganisms. Tr. Vsesoyuzn. n.i. in-ta s.-kh. mikrobiol., vol. 16, pp. 105-108.

22. ALEEM, M. L. H., and M. ALEXANDER. 1960. Nutrition and physiology of Nitrobacter agilis. Appl. microbiol., 8(2):80-84.

23. ALLISON, F. E., and R. G. COVER. 1960. Rates of decomposition of shortleaf pine sawdust in soil at various levels of nitrogen and lime. Soil Sci., 89(4):194-201.

24. ALLISON, F. E., et al. 1960. The effect of partial pressure of oxygen on denitrification in soil. Soil Sci. Soc. America Proc., 24(4):283-285.

25. ANDERSON, O. E. 1960. The Effect of low temperatures on nitrification of ammonia in Cecil sand loam. Soil Sci. Soc. America Proc., 24(4):286-289.

26. Biological studies of some tussock-grassland soils.—12. Soils and vegetation of two cultivated sites and soils. 15. Stout, J. D., Bacteria of two cultivated soils. 16, Ross, D. J., Non-symbiotic nitrogen-fixing bacteria of two cultivated soils. 18. Ross, D. J., Nitrifying activities of two cultivated soils. N. Z. J. Agric. Res., 1960, 3:197-202, 214-223, 224-229, 230-236.

27. CORNFIELD, A. H. 1959. Metabolism of nitrogen during longterm incubation of soil treated with tresh and rotted organic materials. J. Agric. Sci., 53(3):327-329.

28. ENO, C. F. 1960. Nitrate production in the field by incubating the soil in polyethylene bags. Soil Sci. Soc. America Proc., 24 (4):277-279.

29. ISWARAN, V. 1960. Characteristics of azotobacter chroococcum, isolated from a Delhi soil. J. Indian Soc. Soil Sci., 8 (1):57-63.

30. KIAUS, H. 1960. Das Pilspektrum einer Bodenprobe. I. Nachweis der Homogenität.—Arch. Mikrobiol., 35(2):181-195.

31. LOUB, W. 1960. Die microbiologische Charakterisierung von Bodentypen. Bodenkultur, Ausg. A., II, 1:38-70. Bibliog. 69-70.

132. MITCHELL, R., and M. ALEXANDER. 1960. Microbiological changes in flooded soils. Bact. Proc., 28. Soils and Fertil., No. 4: 1661.

133. PARKER, C. A., and P. B. SCUTT. 1960. The effect of oxygen on nitrogen fixation by Azotobacter. Bioch. Biophys. Acta, 38(2): 230-238.

134. SEN, A., et al. 1960. Relationship of the values of available phosphate as determined by chemical methods with nitrogen fixation in soils by azotobacter. J. Indian Soc. Soil Sci., 8(1):65-69.

135. ROUZTT, J. W., et al. 1960. Statistical evaluation of the rhizosphere effect. Soil Sci. Soc. America Proc., 24(4):271-273. Bibliog. pp. 272-273.

136. WEISER, J. 1959. The bacterial flora of the air in agricultural areas.—Ref. Bull Res. Counc. Israel. Sect. E., Expl. Med., 8 E, N 1 2, p. 50.

137. YATAZAWA, M., et al. 1960. Effect of allyl alcohol on micro-population of prairie soils and growth of tree seedlings. Soil Sci. Soc. America Proc., 24(4):313-316.

SOIL FERTILITY, FERTILIZER, TILLAGE

138. ABROSIMOVA, L. N. 1960. Synthetic structure-formers increase soil fertility. S. kh. Sev.-Zap. zony, No. 8:14-15.

139. BAGDYKOV, N. I. 1960. Frit as microbiological fertilizer. Tr. Rostovsk. otd. botan. o-va, vyp. 1, pp. 164-170. Bibliog. 8 refs.

140. BAYTKANOV, K. A. 1960. Some results of a comparative study of the nutrient regime of soils in fallow. Doklady Kazakhsk. akad. s.-kh. nauk, vyp. 2, pp. 71-75. Summary in Kazakh language.

141. BALEV, P. M. 1960. Theoretical basis and practical means of deepening and improving old plowed clay loams of the sod-podzolic type. Izv. Timiryazevskoy. s.-kh. akad., vyp. 4, pp. 98-113. Bibliog. pp. 112-113.

142. BAKHTIN, P. U. 1960. Tillage of soil with various plowing rates. Zemledeliye, No. 9:pp. 39-42.

143. BOLOTINA, N. I. 1960. Dynamics of nitrogen and of phosphorus under conditions of irrigation on near-Caucasus chernozems of Rostov Oblast'. Tr. Pochv. in-ta im. Dokuchayeva, vol. 55, pp. 67-112. Bibliog. 17 refs.

144. BOLOTINA, N. I. Experience with liming and supplying perennial grasses with mineral fertilizers. Ibid., pp. 185-264. Bibliog. 4 refs.

145. GINZBURG, K. YE. Importance of sesquioxides and of humates in the adsorption of phosphorus by soils. Ibid., pp. 239-271. Bibliog. pp. 268-271.

146. GUSEYNOV, D. M. Some results of the study of the effectiveness of new types of fertilizer under Azerbaydzhan conditions. Izv. Akad. Nauk AzSSR. Ser. biol. i med. nauk, No. 2:95-102.

147. GUSEYNOV, R. K. 1960. Study of agricultural chemical properties of soils of the effectiveness of mineral fertilizers in Azerbaydzhan for 40 years. Izv. Akad. Nauk AzSSR. Ser. biol. i med. nauk, No. 2:115-118.

148. GOROZHANKINA, O. S. 1960. Role of plant indicators in the agricultural evaluation of soils. S. kh. Sev. Kavkaza, No. 8:34-35.

149. DAVYDOV, G. A., and YA. M. DENISYUK. 1960. Tillage of solonetz soils in relation to their moisture content. Zemledeliye, No. 9:57-59.

150. DAL'SKIY, N. I. 1960. Two-level plowing of solonetz soils. S. kh. Povolzh'ya, No. 8:25-26.

151. DASHEVSKIY, L., and T. ANTONOVA. 1960. Diagnostics of the use of fertilizer in the beet sowing zone. S. kh. Kirgizii, No. 7:38-42.

152. DOLOTOV, V. A. 1960. Question of agricultural management of the soils of the Vologda Oblast'. Sb. rabot Tsentr. muzeya pochvovedeniya im. Dokuchayeva, vyp. 3, pp. 192-202. Bibliog. pp. 201-202.

153. ZAKHAROV, S. S. 1960. Effect of field and forage-crop rotations on conditions of soil fertility. Tr. Belorusk. s.-kh. akad., vol. 32, vyp. 2, pp. 35-47. Bibliog. 8 refs.

154. ZINOCHKIN, A. G. 1960. Evaluation of soils in relation to yields of grain crops in state variety network. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 59-64. Bibliog. 8 refs.

155. IVANOVA, O. A., and I. P. SIMONOV. 1960. Effectiveness of tillage of soils by Mal'tsev's method in the Central Trans-Ural. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 145-156.

156. KIROSHKA, I. 1960. Salinity of valley soils of Moldavia and their agricultural utilization (exemplified by the valley of the Botna River). Zemledeliye i zhivotnovodstvo Moldavii, No. 9:40-43.

157. KORABLEVA, L. I. 1960. Agronomic properties of sod-podzolic soils of the Moscow Oblast' and the effectiveness of fertilizers in them. Tr. Pochv. in-ta im. Dokuchayeva, vol. 55, pp. 126-157. Bibliog. 26 refs.

158. KORABLEVA, L. I. 1960. Magnesium feeding of plants on sod-podzolic, sandy and sandy loam soils. Tr. Pochv. in-ta im. Dokuchayeva, vol. 55, pp. 192-221. Bibliog. 43 refs.

159. KORNILOV, M. F. 1960. Schist ash: its composition, properties and conditions for its utilization in liming soils. Nauchn. tr. (Sev.-Zap. n.-i. in-t s. kh.), vyp. 1, pp. 278-310. Bibliog. p. 310.

160. KORNILOV, M. F., and Z. V. TRUNINA. Some physiological and biochemical peculiarities in the development of wheat and barley in relation to the reaction of the soil. Ibid., pp. 223-236. Bibliog. 5 refs.

161. KORNILOV, M. F., Z. V. TRUNINA, and V. P. ILLYUVIYEVA. New varieties of industrial lime wastes and their effectiveness in liming podzol soils. Ibid., pp. 257-277.

162. LAVROV, A. V. 1960. Forecasts in distinguishing groups of agricultural biochemical areas of the Ural. Tr. Sverdl. s.-kh. in-ta, vol. 7, pp. 65-87. Bibliog. 38 refs.

163. MATYSHUK, I. V., P. I. TIMOSHIN, and SH. A. CHULAKOV. 1960. Changes in properties of virgin soil under the influence of tillage and the root systems of spring wheat. Tr. In-ta pochvovedeniya Akad. Nauk KazSSR, vol. 11, pp. 60-91. Bibliog. pp. 89-91.

164. MEL'NIKOVA, M. K., L. S. DOTSENKO, and A. D. KUDELYA, et al. 1960. Radiostrontium and possibilities of reducing of its adsorption by plants from the soil. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 210-216. Bibliog. 16 refs.

165. MIKHALEV, N. N. 1960. Effectiveness of fertilizer in relation to improvement of podzol soils. Tr. Vsesoyuzn. n.-i. in-ta udobr. i agropochvoved., vyp. 34, pp. 139-152. Bibliog. 30 refs.

166. MUZYCHKIN, YE. T. 1960. Fertilizing agricultural crops under irrigation on the pre-Caucasian chernozems of the Rostov Oblast'. Tr. Pochv. in-ta im. Dokuchayeva, vol. 55, pp. 3-66. Bibliog. 20 refs.

167. NIKISHKINA, P. I. Action of boron on the development of plants with various conditions of nutrition. Ibid., pp. 222-238. Bibliog. 13 refs.

168. ONIANI, D. I. 1960. Influence of continuous fertilization of tea plantation on several properties of red earths and podzolic soils. Subtrop. kul'tury, No. 2:47-60. Bibliog. 14 refs.

169. REVUT, I. B., and I. I. KOCHUROVA. 1960. Some new possibilities of increasing the fertility of the sub-plow layer of sod-podzolic soils. Sb. tr. po agr. fizike (Agrofiz. n.-i. in-t Vsesoyuzn. akad. s.-kh. nauk), vyp. 8, pp. 143-152. Bibliog. 8 refs.

170. RUBINSHTEYN, M. I., and Z. I. SHLAVITSKAYA. 1960. Peculiarities of the water

and nutrient regimes of dry land soils of southeast Kazakhstan. Doklady Kazakhsk. akad. s.-kh. nauk, vyp. 2, pp. 57-62. Summary in Kazakh language.

171. STANKOV, N. Z. 1960. Patterns in the growth of the root system of field plants. Tr. Vsesoyuzn. n.-i. in-ta udobr. i. agropochvoved., vyp. 34:196-215. Bibliog. 16 refs.

172. SYASINA, G. N. 1960. Effect of various amounts of lime on physiological processes. and biochemical composition of clover. Nauchn. tr. (Sev.-Zap. n.-i in-t s. kh.), vyp. 1, pp. 237-256.

173. TIKHOVA, YE. P., and YU. G. CHURILINA. 1960. Effect of plowing without a moldboard on physical-chemical properties of the soils of the "Razdol'ye" state farm (sovkhoz) of the Voronezh Oblast'. Nauchn. dokl. vyssh. shkoly. Biol. nauki, No. 3:199-203. Bibliog. 6 refs.

174. FEDOSEYEV, A. P. 1960. Utilization of the index of depth of wetting soils in the spring in agricultural practice. Doklady Kazakhsk. akad. s.-kh. nauk, vyp. 2, pp. 79-81. Summary in Kazakh language. Bibliog. 6 refs.

175. FEDOROVSKIY, D. V. 1960. Dynamics of potassium under irrigation on the pre-Caucasian chernozems of the Rostov Oblast'. Tr. Pochv. in-ta im. Dokuchayeva, vol. 55, pp. 113-125. Bibliog. 16 refs.

176. KHEYFETS, D. M. Distribution of phosphorus and of potassium in the soil of rhizosphere and outside of it. Ibid., pp. 165-191. Bibliog. 33 refs.

177. TSERLING, V. V., and G. M. SHCHEGLOVA. Utilization and distribution in the organs of plants of phosphorus from fertilizing for various levels of available phosphorus. Ibid., pp. 272-284. Bibliog. 14 refs.

178. TSERLING, V. V. 1960. New express-method of plant diagnostics. Vestn. Akad. Nauk SSSR, No. 8, pp. 81-83.

179. CHIZHEVSKIY, M. G., and A. P. ABRAMCHUK. 1960. Results and current tasks of developing correct tillage of sod-podzolic soils in the BSSR. Sb. nauch. tr. (Belorusk. n.-i. in-t zemledeliya Akad. s.-kh. nauk BSSR). vyp. 6, pp. 3-17. Bibliog. 21 refs.

180. CHIRIKOV, F. V., and P. P. SOLOV'YEV. 1960. Action of mineral fertilizers and of wood ashes on the conversion of nitrogenous and phosphoric compounds of the soil. Tr. Vsesoyuzn. n.-i. in-ta udobr. i agropochvoved., vyp. 34, pp. 3-37. Bibliog. 36 refs.

181. CHIRKOVA, R. A. 1960. Regime of nutrient substances in soils of rice fields of the Kzyl-Ordinsk Oblast'. Izv. Akad. Nauk KazSSR, Ser. botan. i pochvoved., vyp. 3, pp. 42-53. Summary in Kazakh lang. Bibliog. p. 53.

182. SHEVCHUK, V. YE. 1959. Dynamics of readily hydrolyzable nitrogen and of available phosphates of the soil under the influence of green manure and of manure. Izv. Irkutsk. s.-kh. in-ta, vyp. 14, pp. 73-83.

183. SHEVCHUK, V. YE. Experience in the use of micro-nutrient fertilizers on gray forest weakly podzolized clay loams of the Irkutsk Oblast'. Ibid., pp. 17-29. Bibliog. 8 refs.

184. SHKONDE, E. I. 1960. Effect of plants and of fertilizers on the distribution of phosphates in the soil profile. Tr. Vsesoyuzn. n.-i. in-ta udobr. i agropochvoved., vyp. 14, pp. 153-180. Bibliog. 49 refs.

185. AGERBERG, L. S. 1959. The influence of fertilizers on the quality of crops. I. Slattervaller. Uppsala, 32 pp.

186. ALTEN, F., and A. NIEMANN. 1959. Beziehungen zwischen Reifezustand, Phosphatstoffwechsel und Kaliumernährung. Agrochimica, 3(3):223-230.

187. BERGMANN, W. 1959. Ein Vergleich zwischen Einzel- und Volldüngeranwendung. Dtsch. Landwirtsch., 10:496-500.

188. BERGMANN, W. 1959. Vergleichende Düngungsversuche mit Einzel- und Volldüngern. Dtsch. Landwirtsch., 11:530-533.

189. CHANDRA, P., and W. B. BOLLEN. 1959. Effect of nitrogen sources, wheat straw and sawdust on nitrogen transformations in a subhumid soil under greenhouse conditions. Indian Soc. Soil. Sci., 7(3):115-122.

190. Chemical changes in an irrigated soil during 28 years of differential fertilization. Berkley, Calif., pp. 381-420. (Hilgardia. Vol. 28, No. 15). Bibliog. pp. 419-430.

191. DARCHEVILLE, M. 1960. Etude de la valeur fertilisante de quelques engrais phosphates. Rev. Agric., 13(5):526-530.

192. DHAR, N. R. 1959. Organic substances and calcium phosphates in fertility improvement. An. Edafol. y Fisiol. Veget., 18(6): 417-462.

193. DOLL, E. C., et al. 1960. Initial and residual effects of rock phosphate and superphosphate. Agron. J., 52(5):247-250.

194. FINCK, A. 1960. Untersuchungen zur Manganversorgung von Feldpflanzen auf einigen Bodentypen Schleswig-Holsteins. Z. Pflanzenernähr. Düng., Bodenkunde, 89 134, 2 3:120-127. Bibliog. pp. 136-137.

195. GROS, A. 1960. Ehrgrais.—Guide pratique de la fertilisation. 2 ed. Paris, 408 pp.

196. HOFFMAN, O. 1959. Herstellung von Analysenproben organisch-mineralischer Düngemittel. Landwirtsch. Forsch., 12(4):

276-279.

197. Hundert Jahre erfolgreiche Düngewirtschaft. Generalberichte des 3 Weltkongresse für Düngungsfragen mit allen Diskussionsbeiträgen. Frankfurt a M., 1958, 268 pp.

198. KIRSCH, P.K. 1960. Effects of sawdust mulches. I. Soil properties. Oreg. Agric. Exp. Sta. tech. Bull., 1959, 49, 16 pp. Ref.: Soils and Fertilizers, No. 3:1257.

199. KRESGE, C.B., and D.P. SATCHELL. 1960. Gaseous loss of ammonia from nitrogen fertilizers applied to soils. Agron. J., No. 2:104-107.

200. LASKE, P. 1960. Zum Problem der Nährstoffbilanz des Bodens. Z. Pflanzenernähr., Düng. Bodenkunde, 90(135)1 2: 114-115.

201. LEIN, H. 1960. The effect of phosphate and nitrogen fertilizing on yield and chemical composition of some grass species and white clover in pastures. In Norwegian. Forskn. og. Forsok. bandbr., 1960, II, pp. 203-253. Ref.: Soils and Fertil., No. 4:1866.

202. LIU, W.L., YU. T.J. 1958. Effect of the method of application of superphosphate on its availability in paddy soils. Trudy Pochven. in-ta, Pekin, No. 33:83-90.

203. LOUW, H.A., and D.M. WEBLEY. 1959. A Study of soil bacteria dissolving certain mineral phosphate fertilizers and related compounds. J. Appl. Bact., 22(2):227-233.

204. MARIAKULANDAI, A., and S.R. THYAGARAJAN. 1959. Longterm manurial experiments at Coimbatore. Indian Soc. Soil Sci., No. 4:263-273.

205. MATTHEWS, B.C., and C.G. SHERRELL. 1960. Effect of drying on exchangeable potassium of Ontario soils and the relation of exchangeable potassium to crop yield. Canad. J. Soil Sci., No. 1:35-41.

206. McKELL, C.M., and W.O. WILLIAMS. 1960. A lysimeter study of sulfur fertilization of an annual-range soil. J. Range Manag., 13(3):113-117. Bibliog. 17 refs.

207. MEHTA, B.V., and R.S. DESAI. 1959. Salt tolerance studies. Effect of soil salinity on the growth and chemical composition of plants. Pt. I. Soil a. Water Conservat. India, No. 2-3:101-105. Pt. 2P106-115.

208. PAAUW, F. VAN DER. 1960. Die optimale Versorgung von Boden und Pflanze mit Phosphor. Landwirtsch. Forsch., Sonderht., 14(7):55-60.

209. QUADE, J. 1960. Stickstoffanlieferung des Bodens und Düngerstickstoffwirkung bei Getreide unter wechselnden Bodenverhältnissen. Z. Acker- und Pflanzenbau, III (2): 191-203. Bibliog. 20 refs.

210. RAI, M.M. 1959. Influence of potassium ions on loss of nitrogen from sodium nitrate when applied to soils along with organic matter. Indian Soc. Soil Sci., No. 3:123-125.

211. RENDIG, V.V., and E.A. McCOMB. 1959. Effect of nutritional stress on plant composition.—I. The interaction of added nitrogen with varying sulfur supply. Soil Sci. Soc. America Proc., 23(5):377-380.

212. ROCHE, P., et al. 1959. Utilisation du diagnostic foliare de l'arachide dans le secteur de conservation des sols Vallée—Temoin Lac Alaotra. Agron. trop., Paris, 14:165-197.

213. SAUERLANDT, W. 1960. Phosphor im Stalldünger. Landwirtsch. Forsch., Sonderht. 14(7):38-43.

214. SCHACHTSCHABEL, P. 1960. Umwandlung der Düngerphosphate im Boden und Erfügbarkeit des Bodenphosphors. Landwirtsch. Forsch. Sonderht., 14(7):30-37.

215. SCHEFFER, F., and F. LUDWIG. 1960. Bestimmung künstlichradioaktiver Isotope der seltenen Erden in pflanzlichen Futter- und Nährungsmitteln. Landwirtsch. Forsch., 12(4):280-289.

216. SCHEFFER, F., and B. ULRICH. 1960. Lehrbuch der Agrikulturchemie. 3. Teil. Humus und Humusdüngung. Bd. I. Morphologie, Biologie, Chemie und Dynamik des Humus. Stuttgart, 266 pp.

217. SCHILLER, H. 1959. Mehrjährige bodenkundliche und ergänzende betriebswirtschaftliche Ergebnisse von Düngerbeispielsbetrieben. In the book: Festschr. sechsigjähr. Best. Landw. —Chem. Bundes Vers. Anst. Linz, pp. 215-239. Ref.: Soil and Fertilizers, 1960, No. 5, r. 2138.

218. SCHMALFUSS, K. 1960. Mineraldüngung, Pflanzenertrag und organische Bodensubstanz. Z. Pflanzenernähr., Düng., Bodenkunde, 90(135)1 2:50-58. Bibliog. pp. 57-58.

219. SCHMITT, L. 1960. Ueber die Ausnutzung und Nachwirkung der mineralischen Düngungsphosphorsäure. Landwirtsch. Forsch. Sonderht. 14(7):49-54.

220. SHAW, W.M., and B. ROBINSON. 1960. Reaction efficiencies of liming materials as indicated by lysimeter leachate composition. Soil Sci., 89(4):209-218.

221. SITTON, B.G., et al. 1959. Effects of mulch, nitrogen, and potassium fertilizers on Savannah soil and tung trees. Proc. Ame Soc. Hort. Sci., 74:236-244.

222. Some environmental factors influencing radiostrontium uptake by plants. 1960. Plant and Soil, No. 1;41-48.

223. STEPHENS, D. 1959. Field experiments with trace elements on annual food crops in Ghana. Emper. J. Exptl. Agric., No.

108:324-332.

224. STEPHENS, D. 1960. Fertilizer trails on peasant farms in Ghana. Emper. J. Exptl. Agric. No. 109:1-15.

225. WALKER, T. W. 1960. Soil fertility and herbage productivity. J. Brit. Grassland. Soc., 15(1):74-80.

226. ZOTTL, H. 1960. Methodische Untersuchungen zur Bestimmung der Mineralstickstoffnach lierferung des Waldobens. Forstwiss. Cbl., 79(3-4):72-90. Bibliog. pp. 88-90.

MELIORATION OF SOILS

227. ANTIPOV-KARATAYEV, I. N. 1960. Physico-chemical investigations in connection with melioration of solonetz soils. Izv. Akad. Nauk SSSR, Ser. biol., No. 3: 364-379. Bibliog. pp. 378-379.

228. BADENKO, II. 1960. Leaching as a means of combating secondary salinization of soil. Doklady Kazakh. akad. s.-kh. nauk, vyp. I, pp. 56-63. Summary in Kazakh language.

229. BEYROM, S. G., YE. V. MIKHAYLOVA, and S. N. SELYAKOV. 1959. Meliorative regionalization of Kulunda. Tr. Biol. in-ta (Sib. otd. Akad. Nauk SSSR), vyp. 4, pp. 5-17, with maps. Bibliog. 7 refs.

230. BEKHTEREVA, A. F., V. P. KUSHNARENKO, G. M. SIROTIN, and T. D. SHERNITSA. 1960. Cultivation of the solonetz soils of the Kurgansk Oblast'. Sov. Zaural'ye, 47 pp. with illustr.

231. BOTOV, T. G. 1960. Radical improvement of solonetz soils by the method of redistribution of the genetic horizons of the soil. Tr. Stalingr. s.-kh. op. st., vyp. I, pp. 19-32.

232. BURDYGINA, V. S. 1959. Dynamics of soil salts under the influence of leaching in the Murgabsk Oasis. Avtoref. dis. na step. kand. s.-kh. n. (Akad. Nauk TurkmSSR, Otd. biol. nauk), Ashkhabad, 16 pp.

233. Reports of Soviet soil scientists to the VII International Soil Congress in the USA. Izd. Akad. Nauk SSSR. 1960. Commission VI. Daraseliya, M. K., Means of restoring the fertility of eroded red earths of Georgia (Gruziya), pp. 389-394; Antipov-Karatayev, I. N., Physico-chemical investigations in connection with the amelioration of solonetz soils, pp. 395-404; Balyabo, N. K., Differentiation of means of reclaiming steppe solonetz soils, pp. 405-411; Rozanov, A. N., Ancient agriculture and evolution of soils, pp. 412-420. P'yavchenko, N. I., Circulation of nitrogen and of ash elements in basic types of swamp forests, pp. 421-426; Lupinovich, I. S., Changes in physical and biochemical properties of peat-bog soils under the influence of melioration and of agricultural utilization, pp. 427-437; Vadyunina, A. F., Changes in the process of soil formation in the chestnut zone under the influence of aforestation, pp. 435-444; Shubin, V. G., Winter pre-irrigation as a means of combating drought and over heating of the soil, pp. 445-450.

234. Meliorative improvement of the soils of Azerbaydzhan. (Sb.). In-t gidrotekhn. i melioratsii. Akad. s.-kh. nauk AzSSR, Baku, 1960, 167 pp. with illustr. and maps. In Azerbaydzhanian.

235. Melioration of solonetz in the chernozem zone of European SSR. (Collection of works edited by I. N. Antipov-Karatayev. Akad. Nauk SSSR. Pochv. in-t im. Dokuchayeva). Moscow. Izd. Akad. Nauk SSSR, 1960, pp. 263, with illustr. Contents: Antipov-Karatayev, I. N., I. A. Yurin, G. M. Kader and L. A. Frolkina. Comparative tests of new complex agricultural forest-melioration and agrotechnical methods of mastering soda-sulfate solonetz soils in the Central Chernozem belt (TsChP), pp. 5-219, with illustr. Bibliog. 94 refs.; Semenova-Zabrodina, S. P., and Z. A. Neryad, Means of improving solonetz and chestnut solonetz soils of the south of the Ukraine under dry farming conditions, pp. 220-263. Bibliog. 25 refs.

236. MOCHUL'SKIY, S. K. 1960. Growing perennial grasses on solonetz soils. Tr. Stalingr. s.-kh. op. st., vyp. I, pp. 52-60.

237. MOCHUL'SKIY, S. K. Melioration of solonetzes of the steppe. Ibid., pp. 5-18. Bibliog. 24 refs.

238. BLOODWORTH, M. E. 1959. Some principles and practices in the irrigation of Texas Soils. Tex. agric. Exp. Sta. Bull., No. 937, 55 pp.

239. MOLENAAR, A. 1960. Irrigation by sprinkling. Rome—London. 93 pp.

240. SHERMAN, G. D., and D. L. PLUCKNETT. 1960. Land reclamation in Hawaii. Crops and Soils, No. 9:18-19, 38.

SOIL EROSION AND ITS CONTROL

241. GAYEL', A. G., and L. F. SMIRNOVA. 1960. Wind erosion of coarse-textured soils of the chestnut chernozem zone of the USSR. Vestn. Mosk. un-ta. Ser. 6. Biol., pochvovedeniye, No. 2, pp. 51-62. Bibliog. 14 refs.

242. ZAYTSEV, V. 1960. How to increase the erosion control influence of young forest shelter belts. Zemledeliye i zhivotnovodstvo. Moldavii, No. 6:66-68.

243. KOSOV, B. F. 1960. Gully erosion in Siberia. Vestn. Mosk. un-ta. Ser. 5, geogr., No. 3:54-59. Bibliog. 49 refs.

244. OBEDIYENTOVA, G. V. 1960. Erosion cycles in the Lower Volga basin. Izv. Akad. Nauk SSSR. Ser. geogr., No. 3:95-99. Bibliog. 8 refs.

245. PRYAKHIN, A.I. 1960. Landslides of the lower reaches of the Vyatka River. Vestn. Mosk. un-ta, Ser. 4, geol., No. 2:54-59, with maps.

246. SOBOLEV, S.S. 1960. Soil erosion and zonal systems of erosion control measures. In the book: Doklady sov. pochvovedov k VII Mezhdunarodnomu kongressu v SShA, Moscow. Izd. Akad. Nauk SSSR, pp. 383-388. Summary in English.

247. SHIKULA, N.K. 1959. Soil erosion in Stalinsk Oblast' and means of combating it. Sb. rabot za 1953-1958 gg. (Stalinskaya obl. s.-kh. op. st.). Stalino, pp. 126-142. Bibliog. 7 refs.

248. BUTLER, M.D. 1955. Conserving soil. Princeton, N.J., 321.

249. FLACCUS, E. 1960. Landslides and their revegetation in the White Mountains of New Hampshire. Dissert. Abstr., 20, pp. 3484-3485.

250. KOHNKE, H., and R. ANSON. Soil conservation. N.Y., 298 pp.

251. MAZEK-FIALLA, K. 1960. Bodenschutz und Grundzusammenlegung in Niederösterreich. Agrar. Rundschau, No. 1:13-15.

252. Measurement of increase in productivity by adopting soil conservation practices, Pt. 1-2. Soil and Water Conservat. India, 1959, 7(4):45-55.

253. MIRCHANDANI, P.M., and G.K. MANRAI. 1959. Effect of terracing on upland crops. J. Soil and Water Conservat. India, 7(2-3) 73-77.

254. MISHRA, D.X., and R.N. KAUL. 1959. Erosion of soil by wind. J. Soil and Water Conservat. India, 7(4-5):24-27, 34.

255. PRAKACH, M. Importance of "Shelter-Belts" to check wind-erosion. Ibid., pp. 61-66.

256. RAO, V.S. The role of forestry in soil conservation. Ibid., pp. 28-34.

257. SHENG, T.C. Present soil conservation program in Taiwan. Ibid., pp. 69-73, 78.

258. SEN, N.N. 1959. Forestry in soil conservation. J. Soil and Water Conservat. India. 7(2-3):65-67.

259. SING, B. Social and economic aspects of soil conservation. Ibid., pp. 64-65.

260. SINGH, S. Agronomy in soil conservation. Ibid., pp. 62-63.

261. Soil conservation problems. J. Agric. S. Australia, 1960, 63(9):368-375.

262. STRACEY, P.D. 1959. A note on the soil conservation and protection measures in the Hoshiarpur District, Punjab. Soil and Water Conservat. India, 7(4-5):3-7.

263. TEJWANI, K.G. Soil and water conservation in the Ravine Lands of Gujarat. Ibid., pp. 79-84.

264. ZELUW, J.W., and P.J. ZWERMAN. 1960. Soil and water conservation by regulation. J. Soil and Water Conservat., No. 2:60-64.

265. WEAKLY, H.F. 1960. The Effect of HPAN soil conditioner on runoff, erosion and soil aggregation. J. Soil Water Conservat. 15(4):169-171.

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4 issues per year. First issues published: 1958. Current issues published: 1961, Vol. 40, Nos. 1-4.

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